3.26 CLIMATE CHANGE

SYNOPSIS

Summary of Existing Conditions:

Atmosphere: Climate change is increasingly understood to be linked to the accumulation of greenhouse gases (GHGs) in the atmosphere. While Alaska has a high per capita rate of GHG emissions, the state accounts for only about one percent of U.S. GHG emissions and Alaska's contribution to global GHGs is minimal. Most of Alaska's GHG emissions are from the petroleum and natural gas industry, and about one percent Alaska's GHG emissions are from the mining industry.

Water Resources: Although the effects of climate change on surface water resources are complex and difficult to quantify, predicted increases in average precipitation may cause changes in stream flow. Combined with warmer winters and less snow cover, large-scale stream flow changes may impact barge schedules as well as other resources within the Project Area.

Permafrost: Permafrost is predicted to thaw within the Project Area. As permafrost soils warm, organic carbon reservoirs trapped in the ice are mobilized, causing carbon dioxide and methane to be released into the atmosphere. Permafrost stability or anticipated changes to existing permafrost conditions can significantly influence design and construction considerations associated with settlement and ground stability issues. Predicted changes affecting permafrost conditions over the lifespan of a project can affect engineering and construction design.

Biological Resources and Subsistence: Climate change will impact vegetation, and subsequently wetlands, wildlife, fish, and subsistence resources. Climate modeling predicts shifts in vegetation community types to a drier landscape with a higher proportion of shrubs and trees. Some areas may subside with permafrost loss, fill with water, and drain adjacent wetlands. Fire regime shifts may also contribute to landscape-level vegetation pattern change. Vegetation shifts may cause a small net loss of carbon and nitrogen. Species distributions and abundances are likely to change, resulting in changes to ecosystem functions, habitat range, and interconnected food webs.

Expected Effects:

Alternative 1: No Action – Climate change would continue to have effects as predicted within the Project Area. This alternative would not further contribute to climate change in the Project Area, other than climate change inputs already resulting from exploration work and baseline studies.

Alternative 2: Donlin Gold's Proposed Action

Atmosphere

- *Mine Site*: The intensity of direct GHG emissions from project activities at the mine site would be medium (between 1 percent and 10 percent of Alaska annual GHG emissions). The duration of GHG *emissions* would range from temporary (construction) to long-term (operations and closure). GHG emissions at the mine site would be local in extent (within immediate Project Area). Indirect GHG emissions associated with construction and operations of the mine site would result from emissions associated with transporting supplies and construction materials to the mine site. Overall, project impacts on climate change would range from minor to moderate for the mine site.
- *Transportation Facilities and Pipeline*: The intensity of direct GHG emissions from project activities for the transportation facilities and pipeline would be low, with maximum annual GHG emissions being less than 1 percent of Alaska's GHGs. The duration of GHG emissions would range from temporary (construction) to long-term (operations and closure). Direct GHG emissions at the transportation facilities and pipeline would be local in extent. Indirect GHG emissions associated with construction and operations would result from cruise operations of air traffic between Anchorage (or other point of origin) and the mine site airstrip, and ocean traffic. Overall, GHG impacts on climate change associated with the transportation facilities and pipeline under Alternative 2 would be considered negligible to minor.
- In summary, the Donlin Gold Project would overall cause minor impacts to climate change under Alternative 2.

Water and Permafrost

Hydrologic effects due to climate change under Alternative 2 would range from low intensity (e.g., sufficient barge days would be available under a low water climate change scenario to meet proposed shipping needs) to medium intensity (e.g., a faster pit lake filling rate could require changes in water management/treatment strategies in post-closure). The duration of climate change effects would be long-term to permanent, with potential impacts lasting through the life of the project (transportation and pipeline components) and in post-closure (mine site). The extent of project effects would be considered local to regional. The context of climate change effects on water as pertains to the project is considered common to important. Overall effects are considered minor to moderate.

Impacts to and from permafrost due to climate change under Alternative 2 would range from low intensity (e.g., little noticeable additional ground settlement due to climate change) to medium intensity (e.g., design and BMPs at major mine structures and along pipeline are effective in controlling permafrost hazards, differential settlement, and thermal erosion), although specific low probability conditions may exist that could cause medium to high intensity effects (e.g., additional permafrost excavation at toe of WRF). Project–related impacts to climate-altered permafrost would be limited to intermittent areas of permafrost and would be localized beneath facility footprints and cleared areas. Permafrost thaw effects would range from long-term (e.g., settlement and revegetation reach equilibrium within several years) to permanent (i.e., restoration of permafrost not expected). Discontinuous permafrost and climate change are considered common in context based on their regional to global distribution. Overall effects would range from minor to moderate.

Biological Resources and Subsistence

The effects of predicted climate change on vegetation and wetlands under Alternative 2 may increase in later project years due to warming temperatures and altered precipitation patterns, resulting in permafrost loss, vegetation type changes, a general drying trend, and changed fire regime. Fire severity is predicted to increase over time in a warming climate, and the vegetated areas along active roads or other operations areas would be most vulnerable to accidental fire. Shifts in wildlife, fish, or threatened and endangered species (TES) populations may occur due to subsequent habitat and precipitation or temperature changes, affecting subsistence resources as well. Because the effects would be incremental, the intensity of impacts for biological resources and subsistence would be low. The extent would be considered local to regional, and the context would be considered common. Given the expected long range trends of biome shifts, overall effects of climate change on biological resources and subsistence during the life of the project would be minor.

<u>Other Alternatives</u>: The effects of the other alternatives would be very similar to the effects of Alternative 2. Differences for other action alternatives include:

- *Alternative 3A (Reduced Diesel Barging: LNG-Powered Haul Trucks)* would reduce consumption of diesel, reduce barge trips, and reduce tanker trucks compared to Alternative 2. There would be less potential for low water barge impacts (fewer trips needed), but a slight increase in the effects of climate change on permafrost thaw at the Bethel Dock. Overall impacts from GHGs and for biological resources and subsistence would remain minor, and impacts for water and permafrost would be minor to moderate.
- *Alternative 3B (Reduced Diesel Barging: Diesel Pipeline)* would replace the natural gas pipeline proposed under Alternative 2 with a diesel pipeline. GHG emissions and the resulting impacts to climate change under Alternative 3B would be similar to those discussed under Alternative 2 for construction and closure of all project components, as well as for pipeline operations. There would be slightly less climate effects on project use of water resources along the transportation corridor due to fewer barge trips, but slightly more effects along the pipeline (more stream crossings subject to climate-change impacts). Overall impacts from GHGs and for biological resources and subsistence would remain minor, and impacts for water and permafrost would remain minor to moderate.
- *Alternative 4 (Birch Tree Crossing Port)* would have slightly higher GHG emissions during the construction of the longer access road under Alternative 4. During operations,

project–related activities for the transportation facilities would have reduced GHG emissions due to less barging, but increased GHG emissions from the increased travel distance for trucks. There would be less potential for climate-caused low water barge effects, but slightly more climate-caused effects along Crooked Creek ice road. Overall impacts from GHGs and for biological resources and subsistence would remain minor, and overall impacts for water and permafrost would remain minor to moderate.

- *Alternative 5A (Dry Stack Tailings)* would include variations in tailings methods within the mine site that would not cause a substantial change in GHG emissions or impacts to climate change from those identified under Alternative 2. Flexible mine water management and design of operating pond would be able to accommodate climate-caused precipitation effects. Overall impacts from GHGs and for biological resources and subsistence would remain minor, and overall impacts for water and permafrost would remain minor to moderate.
- *Alternative 6A (Modified Natural Gas Pipeline Alignment: Dalzell Gorge Route)* would include an alternative route for part of the natural gas pipeline that would not cause a substantial change in GHG emissions or impacts to climate change from those identified under Alternative 2. With 21 more stream crossings and 10.5 more miles co-located with INHT than Alternative 2, the potential exists for slightly higher climate-caused precipitation and aufeis effects. Overall impacts from GHGs and for biological resources and subsistence would remain minor, and overall impacts for water and permafrost would remain minor to moderate.

3.26.1 DEFINITION

Climate change, for the purposes of this EIS, is defined as "any systematic change in the long-term statistics of climate elements (such as temperature, pressure, or winds) sustained over several decades or longer," occurring due to human causes as well as natural external forces, such as changes in solar emission, slow changes in the Earth's orbit, or natural internal processes of the climate system (AMS 2013).

Many lines of evidence suggest that recent global warming of the past half-century is due primarily to human activities (USGCRP 2014). The likelihood that observed warming since the middle of the twentieth century is a result of human influence has increased from very likely to extremely likely, with the level of confidence having increased from very low to very high (IPCC 2013).

Climate change can therefore also be defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (UNFCCC 1992).

Anthropogenic emissions of greenhouse gases (GHGs) are likely the dominant cause of observed climate warming since the mid-twentieth century (IPCC 2013). Continued emissions of GHGs are predicted to cause further warming and changes in all components of the climate system (IPCC 2013). The GHG most often emitted through anthropogenic activities is carbon dioxide. In 2012, carbon dioxide (CO_2) accounted for about 82 percent of all U.S. anthropogenic GHG emissions (EPA 2014d).

Naturally occurring GHGs (including carbon dioxide, methane, nitrous oxide, ozone, and water vapor) are produced by volcanoes, forest fires, and biological processes. Anthropogenic GHGs include these gases as well as sulfur hexafluoride, perfluorocarbons, hydrofluorocarbons, and chlorofluorocarbons produced by burning fossil fuels, industrial and agricultural processes, waste management, and land use changes. Concentrations in the atmosphere of GHGs from both natural and anthropogenic sources have increased as a result of the industrial revolution (NOAA 2013a). EPA found that these GHG emissions – specifically six key well-mixed GHGs (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) may reasonably be anticipated to adversely affect public health and welfare (EPA 2009a).

3.26.2 REGULATORY FRAMEWORK

EPA has taken several actions to track and develop standards for GHG emissions from mobile and stationary sources under the Clean Air Act. Listed below are promulgated federal regulations on GHGs relevant to the proposed project, and U.S. Department of Transportation (USDOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) guidance on special permits that is pertinent to climate change predictions of permafrost thaw.

3.26.2.1 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

Increasingly, the consideration of GHG emission and the potential effects of climate change have been incorporated into NEPA reviews of proposed federal actions. The Council on Environmental Quality (CEQ) has issued a draft guidance memorandum on when and how to address GHG emissions and climate change in the NEPA process (2014). The guidance indicates that 25,000 metrics tons (MT) of carbon dioxide equivalent (CO_2-e) per year is the reference point above which a quantitative analysis is warranted. All federal agency actions are covered by this guidance (CEQ 2014). As noted in this guidance, the nature of the proposed action and its relationship to climate change must be considered to determine if a detailed analysis is warranted in the EIS. As the proposed Donlin Gold Project would cause an increase of GHG emissions greater than 25,000 MT per year, an analysis in this EIS is warranted.

CEQ also issued guidance on addressing climate change in NEPA analyses.[1]

3.26.2.2 MOBILE SOURCE REGULATIONS

The EPA has implemented regulations for GHG emission standards for light- and heavy-duty vehicles, for heavy-duty engines, and for renewable fuel standards for the purpose of reducing GHG emissions. These regulations and their applicability to the proposed project are discussed in more detail in Section 3.8, Air Quality.

[1] Climate Change Considerations in Project Level NEPA Analysis, January 13, 2009. Found at http://www.fs.fed.us/emc/nepa/climate_change/includes/cc_nepa_guidance.pdf

3.26.2.3 GHG REPORTING

The EPA requires large emitters of GHGs to report GHG emissions annually in order to inform policy makers. Calculations of the six greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) identified in the Kyoto protocol are needed to determine total project GHG emissions. Because CO_2 is the reference gas for climate change, measures of non-CO_2 GHGs are converted into CO_2 equivalent (CO_2-e) based on their global warming potential (GWP) (potential to absorb heat in the atmosphere). GWP's for these covered gases are shown in Section 3.8, Air Quality, Table 3.8-4. These mandatory reporting requirements and their applicability to the proposed project are described in more detail in Section 3.8, Air Quality.

3.26.2.4 GHG PERMITTING

The EPA has incorporated GHG permitting requirements into its New Source Review (NSR) and Title V permitting programs. The ADEC has adopted EPA's Prevention of Significant Deterioration NSR, Nonattainment NSR, and Title V GHG permitting provisions into 18 AAC 50. The ADEC has not incorporated GHG permitting into its minor NSR permit program. Permitting requirements for GHG emissions, and their applicability to the proposed project, are discussed in more detail in Section 3.8, Air Quality.

3.26.2.5 PHMSA SPECIAL PERMITS

PHMSA issues special permits, an order that waives or modifies compliance with a regulatory requirement if the pipeline operator requesting it demonstrates the need and PHMSA determines that granting a special permit would be consistent with pipeline safety. Special permits are authorized by statute in 49 USC § 60118(c), and the application process is set forth in 49 CFR 190.341. PHMSA performs extensive technical analysis on special permit applications and typically conditions a grant of a special permit on the performance of alternative measures that will provide an equal or greater level of safety. Climate change may cause thaw of permafrost in sections of the proposed natural gas pipeline, presenting a challenge for all proposed project phases (construction, operations and maintenance, and closure, reclamation, and monitoring). Alternative pipeline designs to accommodate permafrost thaw effects would be evaluated by PHMSA prior to issuance of a special permit.

3.26.3 AFFECTED ENVIRONMENT

Examples of climate change directly affecting Alaska include increases in temperature and precipitation, extreme weather events, increased permafrost thawing, shrinking glaciers, and coastal erosion from sea level rise (USGCRP 2014; Chapin III et al. 2014). Complex interactions in natural systems presents challenges to quantified analysis of climate change; the following sections discuss interpretation of the best available data, models, and information regarding atmosphere, water resources, permafrost, biological resources, and subsistence to evaluate climate change effects per resource. Models contain inherent uncertainty and limitation, which are discussed in the applicable sections.

3.26.3.1 ATMOSPHERE

Baseline climate conditions (e.g., temperature, rainfall, etc.) are described in Section 3.4, Climate and Meteorology. According to EPA, there is strong evidence (such as warmer air and ocean temperatures, more high-intensity rainfall events, and more frequent heat waves) that climate change is linked to the accumulation of GHGs in the atmosphere (EPA 2012).

Alaska accounts for less than one percent of the total GHG (CO_2-e) emissions in the U.S. annually (Table 3.26-1). GHG emissions from the U.S. represent approximately 18 percent of the worldwide GHG emissions (Environment Canada 2011). Therefore, Alaska's contribution to global GHGs is minimal.

Table 3.26-1: Estimated Annual GHG Emissions (CO_2-e)[1]

Summary Year	GHG Emissions – ALASKA (MMT)1	GHG Emissions – U.S. (MMT)	Alaska vs U.S. GHG Emissions (%)
1990	42.8	6,233	0.69
2000	48.3	7,107	0.68
2005	52.1	7,254	0.72
2010	55.2[2]	6,875	0.80

Notes:

1 MMT = Million Metric Tons

2 Projected emissions.

Source: ADEC 2008b; EPA 2014d.

On a per capita basis, Alaska activities emit about 77 MT of CO_2-e annually, significantly higher than the national average of 25 MT per year CO_2-e (ADEC 2008b). Alaska's high per capita rate, compared to the rest of the country, is influenced by its low population, cold climate, long winters with low light, and greater distances for transport of goods and people. In addition, Alaska is a major producer of oil and gas for export; activities related to oil and gas exploration and production generate GHG emissions (MAG 2009).

Actual GHG emissions are reported to EPA in Alaska under the greenhouse gas reporting program by sector (Table 3.26-2). For calendar year 2013, approximately 64 percent of reported GHG emissions came from the petroleum and natural gas industry, and approximately 1 percent from the mining industry. In the mining category, Red Dog Operations Mine, Coeur Alaska, Kensington Gold Mine, and Hecla Greens Creek Mine emit 152,985 MT per year, 32,469 MT per year, and 24,846 MT per year, respectively.

Table 3.26-2: Annual Reported GHG Emissions by Sector in Alaska[1]

Sector	Metric Tons CO_2-e	Percent of Alaska GHG Emissions[2]
Power Plants	3,451,787	18.8
Petroleum and Natural Gas Systems	11,791,276	64.4
Refineries	1,285,775	7.0
Other	878,119	4.8
Waste	599,667	3.3
Chemicals	103.874	0.6
Mining	24,846	0.6
Total	**18,320,798**	**100.0**

Notes:

1 Calendar year 2013 emissions reported to EPA under the GHG reporting program reflect actual (rather than potential) emissions from large facilities (over 25,000 MT per year) only. Mobile sources of emissions are not required to be reported, thus are not included in the estimates shown in this table

2 Calculated using actual Alaska GHG emissions reported for calendar year 2013.

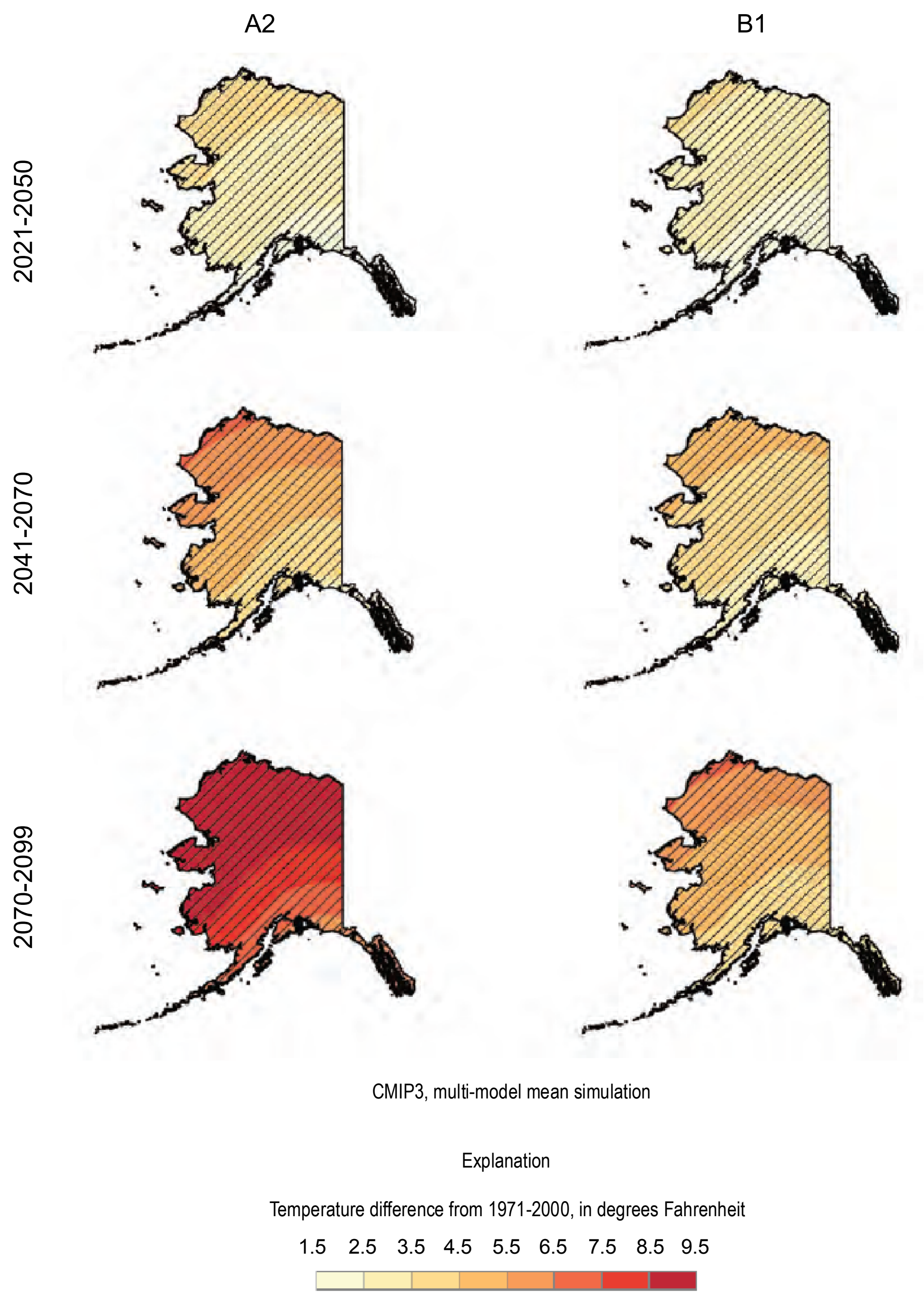
Source: EPA 2014h.

3.26.3.2 WATER RESOURCES

The effect of climate change on surface water characteristics, such as stream flow, within the affected environment of the proposed project is complex and difficult to quantify. BGC Engineering Inc. (BGC) (2011a) reviewed the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report *(*2007) to develop an understanding of climate change predictions for the project. In terms of water resources, precipitation changes may impact stream flow most directly.

The IPCC provides regional climate change predictions of temperature and precipitation for multiple regions in the world, including Alaska. Based on 21 Global Climate Models (GCMs), IPCC (2007) projected that the average precipitation in Alaska could increase by 21 percent by the end of the 21st century. Additionally, the report suggested that significant warming would likely occur, especially during winter months, in the northern portions of Alaska and Canada primarily due to shorter periods of snow cover (Christensen et al. 2007). Average warming by the end of the 21st century in southwest Alaska in the region of the proposed project is projected to range from an increase of 5 to 8degrees Fahrenheit (°F) depending on the GCMs used (Figure 3.26-1) (Chapin III et al. 2014; Markon 2012).

While the Scenarios Network for Alaska + Arctic Planning (SNAP) predictions for precipitation provide an indication of future changes due to climate change that can be compared among different parts of Alaska, potential inconsistencies in historical precipitation records used to make these predictions should be noted. The SNAP (2012) datasets partially narrow the uncertainties of applying a wide range of GCMs to Alaska by using only those GCMs selected based on historical trends (Walsh et al. 2008). Numerous studies evaluation precipitation trends in Alaska differ in analysis period and methodology, and have come to different conclusions, while not addressing the issue of temporal inconsistencies in their datasets (McAfee et al. 2013).



Multi-model mean annual differences in temperature (°F) between the three future periods and 1971–2000, from 15 CMIP3 model simulations. Areas with hatching indicate that more than 50 percent of the models show a statistically significant change in temperature. CMIP3: Coupled Model Intercomparison Project Phase 3; A2: Intergovernmental Panel on Climate Change emissions scenario that assumes a continuation of recent trends in fossil fuel use; B1: Intergovernmental Panel on Climate Change emissions scenario that assumes a vigorous global effort to reduce fossil fuel use.

Data Source: Markon et al. 2012

DONLIN GOLD PROJECT EIS

PROJECTED AIR TEMPERATURE TRENDS IN ALASKA FOR TWO CLIMATE SCENARIOS

NOVEMBER 2015 FIGURE 3.26-1

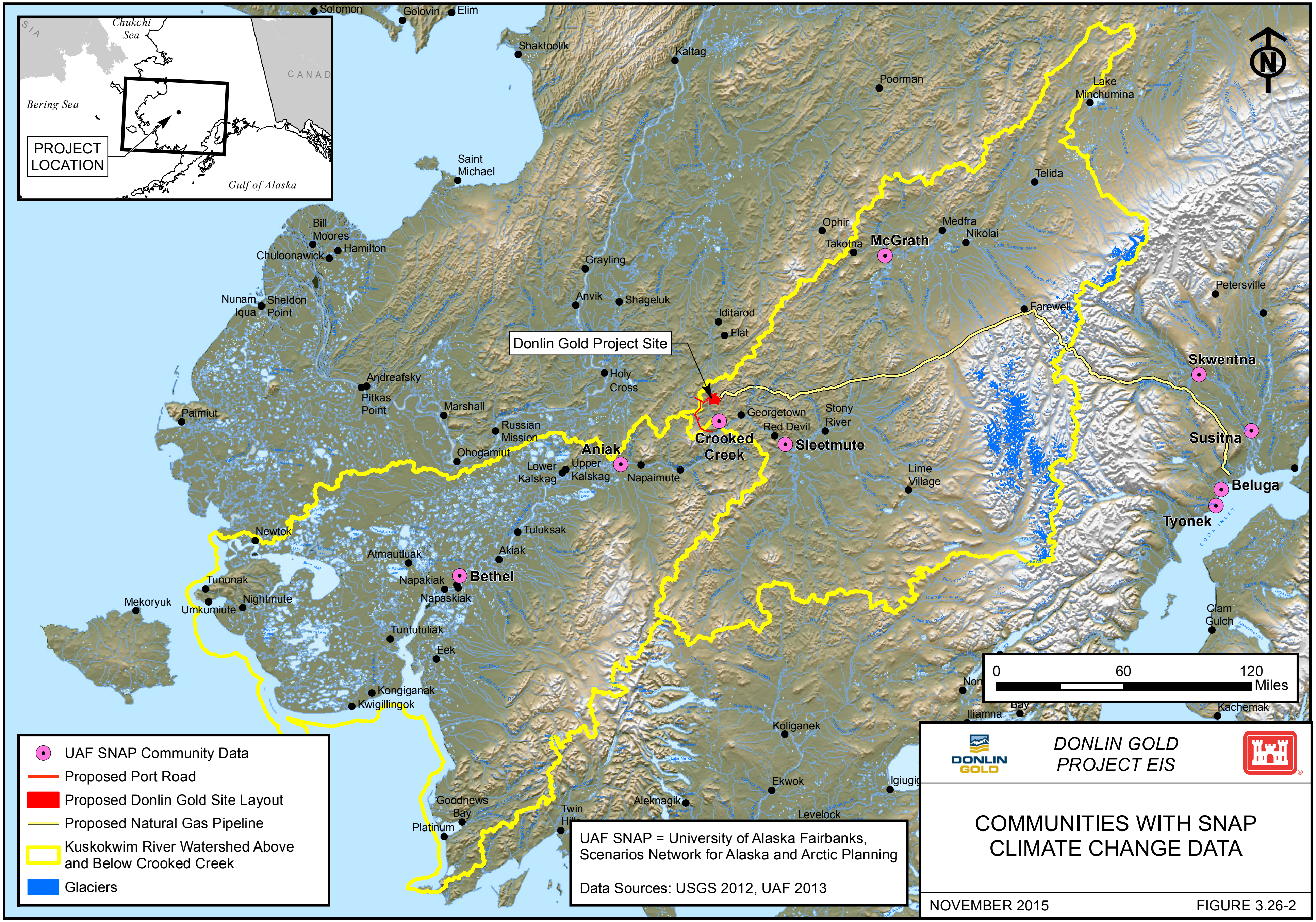
The IPCC predictions for temperature and precipitation are based on relatively large-scale grid cells, as smaller scale grids for climate change predictions are not currently available from the IPCC. In Alaska, however, a collaborative group at the University of Alaska Fairbanks (UAF) known as Scenarios Network for Alaska + Arctic Planning (SNAP) has created down-scaled climate change predictions for the state using five GCMs for Alaska. The five GCMs were selected from a performance evaluation conducted on 15 GCMs by Walsh et al. (2008). This study utilized outputs for an intermediate climate change scenario, where carbon dioxide increases from present day concentrations to 720 parts per million by the year 2100 (known as scenario A1B). The study then determined how each of the 15 GCMs outputs concurred with actual climate data for years 1958-2000 for three climate variables: surface air temperature, air pressure at sea level, and precipitation.

SNAP used the five GCMs for Alaska selected from the Walsh et al. (2008) study to narrow potential uncertainty by generating independent, as well as combined, climate change predictions. SNAP then linked outputs from the five GCMs with historical climate data for Alaska at a 2-kilometer (km) resolution from Parameter Elevation Regressions on Independent Slope Models (PRISM). The predicted results from the GCMs linked with the average monthly PRISM data were used by SNAP to generate pixelated 2-km grids throughout Alaska for average monthly temperature and precipitation for every year out to 2099. From these datasets, SNAP created statewide maps of average monthly temperature and precipitation as well as climate change predictions for 353 communities, including Crooked Creek, located 10 miles south of the proposed mine site, and several additional communities up and down the Kuskokwim River (SNAP 2012) (Figure 3.26-2), as described in the following subsections.

3.26.3.2.1 MINE SITE

BGC (2011a, b) compiled SNAP climate change data for the proposed mine site using Crooked Creek community data as an analog, with the goal of identifying ranges in precipitation that could have an effect on the adequacy of mine infrastructure design. Using a similar approach, Table 3.26-3 presents updated SNAP data from 2012, showing predicted changes in average monthly precipitation at Crooked Creek based on the intermediate climate change scenario A1B for four periods: 2010-2019, 2040-2049, 2060-2069, and 2090-2099. Average monthly precipitation at the mine site is provided alongside Crooked Creek historical data and modeled Crooked Creek SNAP data for the current decade to show the differences in datasets that represent current conditions in the mine area.

Based on the SNAP (2012) modeled data for Crooked Creek, precipitation during winter months (October to March) is projected to increase from current conditions over these decades. Summer months show an increase in precipitation through 2069, then a slight decline in mid-summer through 2099, but a net overall increase for summer months combined. The SNAP data predict a minor increase in precipitation at Crooked Creek (about 2 percent) for the 2040-2049 period, which is less than local historical differences between the mine site and Crooked Creek. More significantly, a 17- to 25-percent increase in precipitation is predicted for the 2060-2099 decades, which represent the post-closure period at the mine.



COMMUNITIES WITH SNAP CLIMATE CHANGE DATA

NOVEMBER 2015 FIGURE 3.26-2

Table 3.26-3: Predicted Precipitation Changes in Mine Area from Climate Change

Month	Crooked Creek Historical Avg. Monthly Precipitation[1] (inches)	Avg. Monthly Precipitation for Mine Site[2] (inches)	Predicted Average Monthly Precipitation[3] (inches)			
			2010-2019 (Construction)[4]	2040-2049 (Operations)[4]	2060-2069 (Closure/ Post-Closure)[4]	2090-2099
January	0.87	1.16	0.98	1.1	1.38	1.34
February	0.59	0.89	0.71	0.71	0.75	0.94
March	0.55	0.80	0.59	0.63	0.71	0.79
April	0.32	0.40	0.32	0.35	0.39	0.47
May	0.67	1.05	0.63	0.63	0.83	0.83
June	1.54	2.15	1.57	1.57	1.97	1.81
July	2.01	2.61	2.24	1.97	2.28	2.17
August	3.35	3.70	3.66	3.66	4.02	4.21
September	2.2	2.66	2.44	2.36	2.76	2.99
October	1.38	1.74	1.3	1.54	1.61	1.89
November	0.91	1.17	0.87	1.06	1.06	1.34
December	0.94	1.30	0.94	1.05	1.18	1.54
Total	**15.33**	**19.63**	**16.25**	**16.64**	**18.94**	**20.32**
% Increase	**-**	**-**	**-**	**2%**	**17%**	**25%**

Notes:

1 Historical average monthly data for Crooked Creek for the period 1961–1990 (SNAP 2012).
2 Synthetic dataset for total precipitation (snowfall plus rainfall) based on data from Crooked Creek, scaled to the proposed Project Area (BGC 2011f) (Also shown in Table 3.4-1, Section 3.4, Climate Change and Meteorology).
3 SNAP (2012) data for the community of Crooked Creek.
4 Approximate phase of the proposed project.

Source: BGC 2011a; SNAP 2012.

An increase in precipitation does not necessarily correlate with an equivalent increase in runoff and stream flow.

3.26.3.2.2 TRANSPORTATION FACILITIES

Water levels on the Kuskokwim River during the construction and operations of the proposed project are of particular interest as the use of the river for barging materials and fuel to the mine is part of the proposed action. Precipitation in the Kuskokwim River watershed represents a significant input for stream flow in the river; therefore, precipitation predictions at several locations along the river were compared. Table 3.26-4 presents the predicted change in average monthly precipitation at five river communities (Bethel, Aniak, Crooked Creek, Sleetmute and McGrath) for two decadal periods (2010-2019 and 2040-2049) based on SNAP (2012) data. These two periods represent construction and later operations of the proposed project, requiring transportation of material and fuel on the Kuskokwim River. Based on the SNAP modeled data, each location is projected to experience an average increase in annual precipitation by approximately 2 to 3 percent from current levels through 2049. On a month-to-month basis, precipitation during winter months (October to March) would generally increase from current conditions, and it appears that most summer months would have a decrease in precipitation at each location.

Aniak and McGrath are projected to have the greatest increase in precipitation during winter months, with changes of 24.1 and 24.6 percent, respectively, which may also indicate an increase in spring breakup flow (Table 3.26-4). The greatest decrease in precipitation during the open water season is predicted to occur in July at Aniak, Crooked Creek, and Sleetmute, with changes of -11.9, -12.1, and -13.1 percent, respectively. Although the predicted change in precipitation during summer months appears to be more negative than positive, the changes are relatively small (all less than -13.1 percent) compared to the winter month increases. Summer low flows are affected by both monthly and seasonal changes in precipitation; therefore, the impacts to stream flow due to decreased precipitation during summer months are likely to be balanced to some degree by possible increases in subsurface flow from increased precipitation during fall and winter. Additionally, a -13 percent change in precipitation does not necessarily suggest that there will be a -13 percent change in stream flow or water depth in the Kuskokwim River.

Local observations of Traditional Ecological Knowledge (TEK), including precipitation-related phenomena, are catalogued by the Alaska Native Tribal Health Consortium (ANTHC 2015) in a statewide Local Environmental Observer (LEO) Network database. For the Kuskokwim River area, these include anecdotal observations of recent low snow years, early breakup, thin river ice, and open water in winter, which may be related to climate warming. For example, observations in Bethel in 2014 document a mild winter, very low snow conditions, and thin river ice in the months of January through April. The LEO Network, which is just getting underway, is intended to become a long-term database that will be used to help track or model climate change effects.

Table 3.26-4: Predicted Precipitation Changes along Kuskokwim River from Climate Change

Month	Predicted Average Monthly Precipitation (inches)														
	Bethel			Aniak			Crooked Creek			Sleetmute			McGrath		
	2010-2019[1]	2040-2049	Precip. Change[2] (%)	2010-2019	2040-2049	Precip. Change[2] (%)	2010-2019	2040-2049	Precip. Change[2] (%)	2010-2019	2040-2049	Precip. Change[2] (%)	2010-2019	2040-2049	Precip. Change[2] (%)
January	0.63	0.75	**19.0**	0.79	0.98	**24.1**	0.98	1.1	**12.2**	0.87	0.94	8.0	0.87	0.91	4.6
February	0.51	0.51	0.0	1.02	1.02	0.0	0.71	0.71	0.0	0.75	0.75	0.0	0.79	0.79	0.0
March	0.63	0.67	6.3	0.94	1.02	8.5	0.59	0.63	6.8	0.59	0.63	6.8	0.79	0.83	5.1
April	0.79	0.79	0.0	0.67	0.71	6.0	0.32	0.35	9.4	0.63	0.67	6.3	0.75	0.87	**16.0**
May	0.75	0.79	5.3	0.98	0.98	0.0	0.63	0.63	0.0	0.67	0.71	6.0	0.79	0.79	0.0
June	1.46	1.61	**10.3**	1.46	1.54	5.5	1.57	1.57	0.0	1.42	1.38	-2.8	1.57	1.46	-7.0
July	2.2	2.01	-8.6	2.68	2.36	**-11.9**	2.24	1.97	**-12.1**	2.13	1.85	**-13.1**	2.32	2.17	-6.5
August	3.31	3.15	-4.8	4.88	4.76	-2.5	3.66	3.66	0.0	3.66	3.74	2.2	2.87	2.95	2.8
September	2.28	2.09	-8.3	2.99	2.87	-4.0	2.44	2.36	-3.3	2.56	2.48	-3.1	2.2	2.13	-3.2
October	1.34	1.61	**20.1**	1.3	1.57	**20.8**	1.3	1.54	**18.5**	1.26	1.46	**15.9**	1.34	1.5	**11.9**
November	1.06	1.26	**18.9**	1.1	1.3	**18.2**	0.87	1.06	**21.8**	0.79	0.94	**19.0**	1.14	1.42	**24.6**
December	1.02	1.1	7.8	1.1	1.22	**10.9**	0.94	1.05	**11.7**	0.87	0.94	8.0	1.46	1.54	5.5
Total	16.0	16.3	2.3	19.9	20.3	2.1	16.3	16.6	2.4	16.2	16.5	1.8	16.9	17.4	2.8

Notes:

1. 2010-2019 represents construction of proposed project, and 2040-2049 late operations.
2. **Bold** data represent changes > 10%.

Source: SNAP 2012.

3.26.3.2.3 NATURAL GAS PIPELINE

Monthly SNAP precipitation data are available for several communities near the pipeline in the Cook Inlet basin, and as mapped decadal averages at a 2-km resolution throughout the less populated parts of the route in the Alaska Range and Kuskokwim Basin (SNAP 2012).

Average annual precipitation in the Cook Inlet basin communities is anticipated to increase about 3 to 4 percent over the life of the project as a result of climate change (Table 3.26-4). In the Alaska Range, Kuskokwim basin drainages, and Kuskokwim Hills, average annual precipitation is predicted to increase on the order of 2 to 15 percent, with the higher increases mapped in the Alaska Range and lower increases in the Kuskokwim Hills and villages along the Kuskokwim River (Table 3.26-4). Most of the increased precipitation at the Cook Inlet locations is predicted to occur as snowfall in winter months (November and January) and during breakup in May. These increases would be balanced in part by drier weather in early summer (e.g., June precipitation decreases). The combined greater winter snowfall and precipitation increases in May suggest that greater discharge could occur during breakup than would be anticipated in the absence of climate change.

Other studies in the Cook Inlet basin that focus on climate modeling later in the century (e.g., Prucha et al. 2011) suggest that much of the expected increased precipitation in winter could occur as rain, and that a reduced snowpack could occur with smaller intermittent melting episodes throughout the winter, rather than a large breakup. As shown in Table 3.26-3 and Table 3.26-4, precipitation changes are expected to be unevenly distributed across different seasons.

Thus, while climate change predictions suggest that an overall increase in precipitation may occur in the vicinity of the mine and along the Kuskokwim River, it is difficult to quantify changes to stream flow given the uncertainties inherent in the predicted precipitation trends and the complex watershed mechanisms influencing runoff. Given the uncertainties and watershed complexities described above, predicted changes in the SNAP data of less than 20 percent, such as summer decreases in precipitation in Kuskokwim River communities, may not be statistically significant or reliable enough to use for stream flow predictions; and further modeling of the data in an attempt to glean implications for water levels would compound these uncertainties.

Table 3.26-5: Predicted Precipitation Changes near Pipeline in Cook Inlet Basin from Climate Change

Month	Tyonek (Alternative 6A)			Beluga (Alt. 2, near MP 0)			Susitna (Alt. 2, near MP 20)			Skwentna (Alt. 2, near MP 50)		
	2010-2019[1]	2040-2049	Precip. Change[2] (%)	2010-2019[1]	2040-2049	Precip. Change[2] (%)	2010-2019[1]	2040-2049	Precip. Change[2] (%)	2010-2019[1]	2040-2049	Precip. Change[2] (%)
January	1.93	2.2	**+14.0**	1.65	1.85	**+12.1**	1.5	1.73	**+15.3**	2.32	2.68	**+15.5**
February	1.5	1.54	+2.7	1.42	1.46	+2.8	1.38	1.42	+2.9	2.13	2.17	+1.9
March	1.22	1.26	+3.3	1.14	1.18	+3.5	1.06	1.1	+3.8	1.54	1.57	+1.9
April	1.3	1.34	+3.1	1.02	1.02	0.0	0.91	0.94	+3.3	1.26	1.3	+3.2
May	1.22	1.42	**+16.4**	1.34	1.54	**+14.9**	1.26	1.42	**+12.7**	1.5	1.61	+7.3
June	1.61	1.5	-6.8	1.73	1.57	-9.2	1.69	1.54	-8.9	2.24	2.05	-8.5
July	2.13	2.13	0.0	2.2	2.2	0.0	2.4	2.4	0.0	2.83	2.76	-2.5
August	3.39	3.54	+4.4	3.82	4.02	+5.2	4.33	4.49	+3.7	4.09	4.25	+3.9
September	4.21	4.25	+1.0	4.65	4.72	+1.5	4.09	4.13	+1.0	4.33	4.37	+0.9
October	3.19	3.43	+7.5	3.27	3.46	+5.8	3.11	3.27	+5.1	3.58	3.78	+5.6
November	2.2	2.4	+9.1	1.81	2.01	**+11.0**	1.5	1.65	**+10.0**	2.05	2.32	**+13.2**
December	2.76	2.68	-2.9	2.36	2.32	-1.7	2.24	2.17	-3.1	3.43	3.35	-2.3
Total	26.7	27.7	+3.9	26.4	27.4	+3.6	25.5	26.3	+3.1	31.3	32.2	+2.9

Notes:

1 2010-2019 represents construction of proposed project, and 2040-2049 late operations.
2 **Bold** data represent changes > 10%.

Source: SNAP (2012) community-based data.

3.26.3.3 PERMAFROST

The presence of permafrost is associated with many components of the proposed project. Permafrost stability or anticipated changes to existing permafrost conditions can significantly influence design and construction considerations associated with settlement and ground stability issues. For these reasons, climatic changes affecting permafrost conditions over the lifespan of a project can affect engineering and construction design.

Permafrost susceptibility to thaw can vary considerably within a narrow range of temperatures referred to as "warm" and "cold" permafrost conditions. Permafrost conditions that are considered "warm" remain just below freezing (32 °F), and cold permafrost conditions remain below 30°F (-1 degree Celsius [°C]) (Markon et al. 2012). Warm permafrost often exists in a fragile thermal equilibrium, and is more susceptible to potential thaw. Permafrost conditions associated with the Project Area are considered warm. This includes the proposed mine site, select segments of transportation facility components (i.e., roads), and localized segments of the proposed pipeline alignment (BGC 2006; CH2M Hill 2011b). Sporadic, discontinuous permafrost in the proposed mine site area is typically less than 31.6°F (BGC 2006). Similarly, discontinuous segments of warm permafrost along the proposed pipeline alignment are typically between 31°F and 32°F (CH2M Hill 2011b).

Mean annual air temperature (MAAT) generally -coincides with permafrost distribution, but does not necessarily correspond with linear warming (temperature) of permafrost (Smith et al. 2010; Markon et al. 2012). Topography, surface water, groundwater movement, soil properties, vegetation, and snow can also affect permafrost in addition to anthropogenic disturbances. Snow depth insulative properties can be as influential as warming temperatures (Jorgenson 2011). Zones of permafrost distribution in the northern hemisphere generally correlate with mean annual air temperatures (Jorgenson 2011) as shown in Table 3.26-6.

Table 3.26-6: Permafrost Zone Correlation to Air Temperature in Alaska

Permafrost Zone	% Area	MAAT Range	% Land Surface by Region of Alaska
Continuous	>90%	21.2°F	32% of northern reaches
Discontinuous	50-90%	21.2 to 28.4°F	31% of south-central and interior
Sporadic	10-50%	28.4 to 32°F°	8% of southern portions
Isolated	0-10%	32 to 35.6°F	10% of southern portions

Notes:

°F – degrees Fahrenheit
MAAT – Mean Annual Air Temperature

Source: Jorgenson 2011; Markon et al. 2012.

Review of Alaska's climate records indicates a seasonally inconsistent 4°F average-annual extended (air) temperature increase from 1949 to 2005. However, southwestern Alaska has seen smallest average-annual temperature increase of 1.8° to 2.5°F (Markon et al. 2012). Regional climate forecasts and projected mean annual temperature range estimates have been modeled for future time periods using two emission-based scenarios (Figure 3.26-1). The A2 scenario assumes a continuation in the recent trend of fossil fuel use, and B1 assumes a vigorous global effort to reduce fossil fuel use (Markon et al. 2012). The projected time period temperature increases for each of the scenarios are listed in Table 3.26-7.

Table 3.26-7: Projected Air Temperature Increases in Alaska for Two Climate Scenarios

Time Period	Scenario B1 MAAT Range	Scenario A2 MAAT Range
2021 to 2050	0 to 4°F	0 to 6°F
2041 to 2070	2 to 6°F	2 to 8°F
2070 to 2099	2 to 8°F	4 to 9.5°F

Notes:

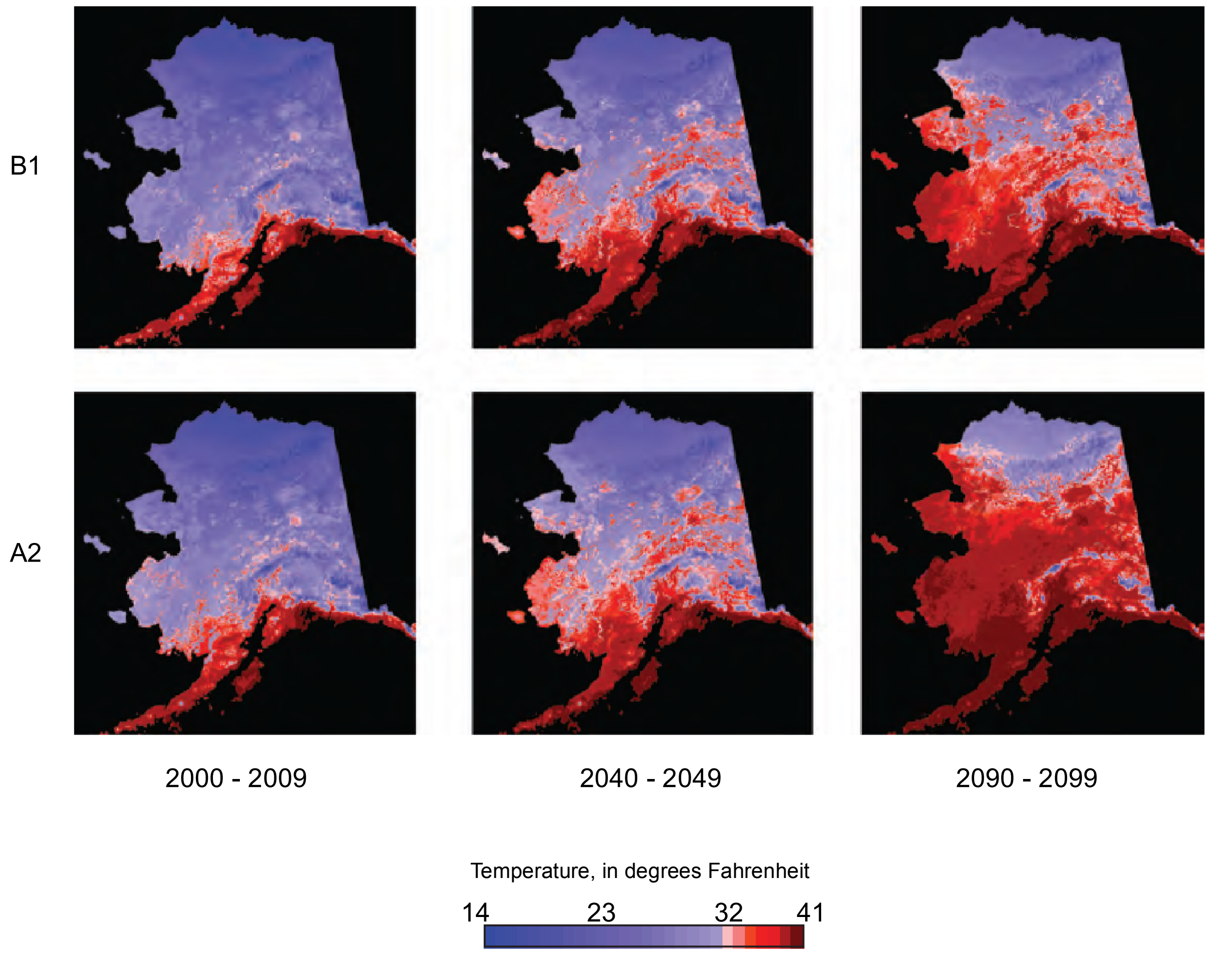
°F – degrees Fahrenheit
MAAT – Mean Annual Air Temperature

Source: Markon et al. 2012.

Permafrost temperature increases of 2 to 5°F have been documented in northern Alaska since the 1980s (Markon et al. 2012). Local observations of permafrost conditions in the Kuskokwim River area note increased permafrost degradation and settlement along traditional use trails associated with the mild winter of early 2014 (ANTHC 2015).

A permafrost degradation model developed by the Geophysical Institute Permafrost Laboratory at UAF, which is driven by climate model outputs (emission scenario projections), predicts a northward expansion of permafrost thaw (Figure 3.26-3). The results from two simulation outputs (temperature and snowfall, based on emission scenarios) and five coupled model intercomparisons (downscaling) (Walsh et al. 2005) project an increase in mean annual ground temperatures at a 3-foot depth in permafrost. Since the proposed project has an estimated lifespan of approximately 37.5 years from construction to reclamation, the projected permafrost model simulations for the 2040–2049 period are temporally applicable to operations, and the 2090-2099 period applicable to about 40 years post-closure. Ground temperature increases projected by the models are on the order of 2°F for the mine area, roughly 2-4°F for the Bethel area, and range from about 0 to 4°F over the length of the pipeline corridor. Increases projected for the 2090-2099 period are in the range of 2-7°F for the mine site and Bethel area, and 0-7°F for the pipeline corridor depending on location and model. Although predictions beyond 2099 are speculative, if warming trends continue, permafrost would continue to degrade beyond the twenty-first century.

Near-future (decadal scale) permafrost considered most vulnerable to surface thaw in a warming environment include warm permafrost (sub-arctic and boreal) and permafrost with high ground ice content in the near-surface (>20 percent excess ice by volume). Thaw effects are generally most pronounced in the upper 33 feet of high-ice-content permafrost, resulting in settlement and thermokarst terrain. Accelerated thawing from future warming could include as much as the top 10 to 30 feet of discontinuous permafrost by 2100 (Markon 2012).



Mean annual ground temperatures at 3-ft depth in permafrost model simulations driven by output from climate models run under B1 (upper panels) and A2 (lower panels) emissions scenarios. As indicated by color bars, blue shades represent temperatures below 32ºF; red shades represent temperatures above 32ºF.

Data Source: Markon et al. 2012

DONLIN GOLD
DONLIN GOLD PROJECT EIS

PROJECTED GROUND TEMPERATURE TRENDS IN ALASKA FOR TWO CLIMATE CHANGE SCENARIOS

NOVEMBER 2015

FIGURE 3.26-3

Melting permafrost can also introduce carbon dioxide and methane into the atmosphere. Currently, the earth's atmosphere contains about 850 gigatons of carbon. Almost twice that amount (about 1,400 gigatons) is estimated to be frozen in the earth's permafrost. As permafrost soils warm, organic carbon reservoirs trapped in the ice are mobilized, causing carbon dioxide and methane to be released. Methane is predominantly released from melting permafrost in wetland habitats such as ponds, lakes, and swamps. Thus, models predict that if climate change results in the region becoming warmer and drier, more carbon dioxide will be released. If the region gets warmer and wetter, more methane will be released. Methane is 25 times more potent at trapping energy as a greenhouse gas than carbon dioxide, resulting in a much larger impact on climate change. The rate, location, and method of how the carbon in the permafrost decays will impact how much carbon is released into the atmosphere.

3.26.3.4 BIOLOGICAL RESOURCES

Expected climate change impacts affecting biological resources within the Project Area include altered hydrology, new fire regimes, ocean acidification, and changing species distributions, abundances, and phenologies. Improved local (downscaled) climate models are increasingly available (SNAP 2015) to assist in planning for change in biological resources with inclusion of more specific variables.

Interpretation of studies on biological responses to climate change should be considered carefully, as many climate change impacts may be masked by species interactions, meaning that responses could be overlooked or misinterpreted as evidence that climate change has no effect on a particular species (Post et al. 2009). Long-term trends post-closure may change as new information, better models, and greater understanding of climate trends is investigated.

3.26.3.4.1 VEGETATION AND WETLANDS

Studies have shown that warming temperatures affect the distributions and growth rates of vegetation, resulting in changes in vegetation community composition, structure, and function. Changes may include a northward expansion of the range of shrubs; increased growth rates of shrubs and graminoids; and decreased cover of mosses and lichens (McGuire 2015; BLM 2012a; Chapin III et al. 2003, 2006, 2008, 2014).

Predictive models, such as SNAP's Integrated Ecosystem Model, forecast large scale biome shifts in Alaska and Northwest Canada in the next 100 years due to warming temperatures, less available water (precipitation and evapotranspiration changes), and changing fire regime. The predicted warmer temperatures in Alaska would likely decrease the duration of snow cover, causing earlier snowmelt and a longer growing season (Euskirchen et al. 2009). The shorter period of snow cover and longer duration of warmer summer months could serve to change the seasonal distribution of river flow and to decrease the size of ponds and wetlands (Jones and Rinehart 2010).

Climate change may not have profound effects on vegetation community type composition during the project life (30 years) or during closure, but changes such as shrub encroachment or wetland shifts may be evident. The time frame of large-scale shifts is expected to be beyond the analysis time of the project life, as most scenarios give a range of outcomes per emissions scenario in decadal increments for vegetation (McGuire 2015; SNAP 2012).

Phenological shifts have been noted in studies and in observations in the LEO Network (ANTHC 2015), such as earlier timing of bud burst in the spring and altered berry production. Warming trends may also increase potential suitable habitat for invasive species (FWS 2009b). Donlin Gold's Invasive Species Management Plan will include adaptive strategies to plan for change.

Vegetation communities with a higher proportion of shrubs and trees will have higher biomass and a greater capacity for transpiration compared to tundra vegetation types. Southcentral Alaska vegetation communities have experienced drying trends in recent decades, resulting in fewer wetlands and a corresponding increase in upland species (Berg et al. 2009; Klein et al. 2005). Higher transpiration, less available water, and a lower albedo caused by woody vegetation increase contributes to a drier landscape with fewer or smaller waterbodies compared to current conditions. Large scale hydrological changes may occur throughout the landscape.

Fire regime changes may be more immediate than vegetation changes during the project life; increased fire frequency and intensity is already evident throughout much of Alaska (Schuur et al. 2014). The Alaska Frame-based Ecosystem Code (ALFRESCO) model focuses on system interaction and feedbacks to predict landscape level change by varying fire intensity and frequency. Results from interior Alaska models indicate that fire frequency changes strongly influence landscape-level vegetation patterns through feedbacks that increase future fire frequency and intensity (SNAP 2012). Landscape models indicate that the mine site area may be subject to more extreme changes than either the pipeline corridor or the transportation corridor because of geography in relation to the area's weather patterns (Rupp and Springsteen 2009).

Permafrost loss is expected due to thawing from positive feedbacks between warming temperatures, increased woody vegetation, and lower-snow winters. Permafrost thaw may cause ground subsidence leading to water-filled depressions. Adjacent areas may then drain, causing a shift from a wetland type or mosaic to an upland type. Most of the Project Area has discontinuous permafrost (with some sporadic or isolated zones), so vegetation community type changes would be variable and difficult to predict.

Permafrost loss, overall drying trends, and vegetation community type shifts may require adapting the project's reclamation and revegetation strategies. Donlin Gold's Stabilization, Rehabilitation and Reclamation Plan would include regular inspection and monitoring of reclaimed or restored sites through the life of the project and after closure to ensure adequate success levels. The Plan will build in adaptive management capacity for alternate approaches due to climate change effects.

Carbon sequestration and loss is another complex aspect of potential vegetation community type changes within the Project Area. Expected effects are low during project life and after closure. Increases in above-ground plant biomass may increase carbon and nitrogen storage, especially with shifts to higher proportions of woody vegetation; however, the subsequent loss of both elements from deep soil layers may offset the gains (Genet et al. 2013). Overall, most tundra carbon storage experiments indicate a small net loss of carbon and nitrogen from vegetation changes, resulting in a net carbon loss within non-forested ecosystems in Alaska (Mack et al. 2004). Reclamation and restoration activities may offset loss by adding fertilizer or other strategies discussed in detail in the Stabilization, Rehabilitation and Reclamation Plan.

3.26.3.4.2 WILDLIFE AND THREATENED AND ENDANGERED SPECIES

Studies in Alaska and the region have begun examining the complex factors in potential climate change impacts to wildlife and birds, but results are limited. Changes to fish and wildlife resources are anticipated by the State of Alaska, and addressed in a climate change strategy to assess likely effects and develop adaptation strategies (ADF&G 2010b). A revised Alaska Wildlife Action Plan contains details of threats and impacts to wildlife populations in Alaska, with provisions for the potential of policy and regulation changes, and adaptive strategies to meet climate change impacts to wildlife and birds (ADF&G 2015m).

Species distributions and abundances are likely to change, resulting in changes to ecosystem functions, habitat range, and interconnected food webs (Liebezeit et al. 2012; Ims and Fuglei 2005). Impacts may be positive or negative. Interior river basins may experience increases in woody vegetation cover and reduction in wetlands, negatively affecting moose and waterfowl habitat. Changing fire regimes may affect wildlife differently; moose may benefit from earlier successional stages, but woodpeckers dependent on old growth forest may be negatively impacted (ADF&G 2010b).Wildfire may also create more potential habitat for invasive species, some of which are toxic or unpalatable to moose or other wildlife species (Chapin III et al. 2014).

Warming conditions may lead to increases in infectious disease in wildlife, or conditions that favor the release of persistent environmental pollutants that can affect the immune system and favor an increased disease rate (Bradley et al. 2005). Increased disease may negatively affect wildlife populations and conditions.

Specific to birds, altered hydrological conditions may affect wetland productivity for migratory birds seasonally dependent on them (ADF&G 2010b). Asynchrony between breeding phenology of migratory bird species and their invertebrate food sources is possible (ADF&G 2010b). Drying of wetlands would result in negative impacts to species that rely on shallow water and wet meadows, and shrub expansion may reduce the quality and availability of some types of habitats. A positive impact is that productivity of some species may increase due to a longer open water season, which may also increase food productivity in aquatic systems.

Coastal dependent bird species such as spectacled eider, identified as a threatened species, may lose habitat if sea levels change (ADF&G 2010b). Changes in marine productivity could negatively affect food webs important to bird species, such as reduction in clam beds used in winter by spectacled eiders. Impacts of climate change to other threatened and endangered species (TES) species (marine mammals) are extremely complex and poorly understood at this time.

3.26.3.4.3 FISH AND AQUATIC RESOURCES

The complex factors contributing to fisheries trends due to climate change are currently being studied in Alaska. Expected changes include species range shifts to fish tolerant of warmer waters; temporal shifts in prey and predators; food web alterations due to temperature and acidification changes; habitat changes such as turbidity increase; or shifts in run timing (ADF&G 2010b; IUCN 2009). Higher water temperatures increasing metabolic stress for fish species could result in lower tolerance thresholds to land-use impacts. A positive effect may be that a moderate increase in water temperature could contribute to a more productive feeding season and enable fish to better survive the winter and additional stress.

For Pacific salmon, the overall trend is that conditions in a few cold-water locations may improve for certain life stages, but the overall impacts of a warming climate are negative (Crozier et al. 2014; IUCN 2009; Tolimieri and Levin 2004). Ocean acidification may affect zooplankton production, affecting species such as sockeye salmon that feed on zooplankton (ADF&G 2010b). In the Pacific Northwest, new literature generally supports previous concerns that climate change will cause moderate to severe declines in salmon, especially with interacting factors such as water diversion, accelerated mobilization of contaminants, hypoxia, and invasive species (Crozier et al. 2014). Warmer temperatures will reduce incubation and cause earlier hatching times, leading to phase mismatch between juveniles and food source (AYK SSI 2006).

Changes in lake stratification due to warmed temperatures may affect freshwater fish species reproduction and distribution patterns. Increased or altered precipitation may enhance nutrient loading in lakes and wetlands, increasing connectivity and potential for cross-lake fish colonization and aquatic system food web changes (Post et al. 2009).

Marine assemblages may also shift northward, or may include increases in predatory fish presence or invasive species habitat more favorable to species such as green crab (ADF&G 2010b).

3.26.3.5 SUBSISTENCE

Limited studies examine the combination of indigenous observations and understanding of climate in the context of climate change. Understanding the multi-scaled interaction of climate with subsistence livelihoods will help anticipate vulnerability and adaptive capacity potential in rural Alaskan communities (McNeely 2009). The small number of jobs, high cost of living, and rapid social change make rural communities highly vulnerable to climate change through impacts on traditional hunting and fishing and cultural connection to the land and waters (Chapin III et al. 2006, 2014). The LEO network partnership provides a broad, expanding network of local observations to help synthesize this understanding over time (ANTHC 2015).

Subsistence harvest opportunities may be affected by potential shifts in hunting seasons. In other cases, shifts in distribution or abundance of favored species may affect harvest opportunity (ADF&G 2010b). Economic losses to coastal and riverine communities may occur as traditional harvest species change their relative location and abundance. Climate change is likely a contributing factor to recent declines in moose populations in unit 19A and Kuskokwim River chinook runs. Landscape changes may alter access by subsistence users, including changes to wetlands or winter access conditions. However, with the current state of knowledge, it is not possible to definitively identify the degree to which climate change, among many other factors, is causing the declines.

One of the most important recent and ongoing effects on subsistence uses due to climate change is less predictable ice thickness and more widespread and frequent instance of open water in the winter. For the Kuskokwim River area, the ANTHC Local Observer Network includes observations for the Kuskokwim River of recent low snow years, early breakup, thin river ice, and open water in winter, which may be related to climate warming. For example, observations in Bethel in 2014 document a mild winter, very low snow conditions, and thin river ice in the months of January through April. These changes and uncertainties make for very dangerous winter ice-travel conditions.

3.26.3.6 SPILL RESPONSE

The effects of project-related spills (described in Section 3.24, Spill Risk) on climate change are considered not applicable. The analyses of spill scenarios are provided within each resource area.

3.26.4 ENVIRONMENTAL CONSEQUENCES

This section addresses direct and indirect impacts on climate change during construction, operations and maintenance, and closure, reclamation, and monitoring from the Donlin Gold Project. Climate change may also affect project impacts on many different resources.

The impact criteria table for climate change and GHG emissions is presented in Table 3.26-8. Impact criteria ratings for other resources affected by climate change follow the criteria tables in Section 3.5, Surface Water Hydrology, and Section 3.2, Soils. Aside from GHG analysis affecting atmosphere, water, and permafrost, this section briefly considers the effects on vegetation and wetlands, which in turn impacts wildlife and TES, and fish and aquatic resources. Subsistence, due to the complex, multi-scaled interaction of climate with subsistence livelihoods, is also briefly considered.

Since an analysis of broad cumulative changes is inherent in the determination of project effects on climate change, discussions of cumulative effects related to climate change are included in this section, summarized for each alternative.

Table 3.26-8: GHG Impact Assessment Criteria for the Donlin Gold Project

Impact Category	Effects Summary		
Magnitude or Intensity	**Low**: GHG project-related emissions are < 1% of the total annual GHG emissions for the State of Alaska[a] (i.e., < 0.521 MMT).	**Medium**: GHG project-related emissions equal to or between 1% and 10% of the total annual GHG emissions for the State of Alaska[a] (i.e., between 0.521 MMT and 5.210 MMT).	**High**: GHG project-related emissions > 10% of the total annual GHG emissions for the State of Alaska[a] (i.e., > 5.210 MMT)
Duration	**Temporary**: GHG project-related emissions would be intermittent and not longer than span of project construction.	**Long-term**: GHG project-related emissions would occur throughout the life of the project.	**Permanent**: GHG project-related emissions would occur beyond the life of the project.
Geographic Extent	**Local**: GHG project-related emissions occur in the immediate Project Area.	**Regional**: GHG project-related emissions occur in the region of the Project Area.	**Extended**: GHG project-related emissions occur beyond the regional scale.
Context	**Common**: Affects usual or ordinary resources; not depleted or protected by legislation.	**Important**: Affects resources protected by legislation.	**Unique**: Affects depleted resources and resources protected by legislation.

Notes:

a Total CO_2-e emissions were 52.1 MMT for the State of Alaska in 2005.

Source: ADEC 2008b; EPA 2014d.

3.26.4.1 ALTERNATIVE 1 – NO ACTION

Under the No Action Alternative, the proposed Donlin Gold Project would not be developed, and Donlin Gold would not establish a mine site, develop transportation facilities, or construct a natural gas pipeline in the proposed Project Area. While this alternative would introduce no new GHG emissions, the effects of climate change would still occur based on existing projections. Existing GHG emissions and related climate change effects on various resources would be the same as described in Affected Environment (above Section 3.26.2).

Over the past 60 years, Alaska has warmed more than twice as fast as the rest of the U.S., with state-wide average annual air temperature increasing by 3°F and average winter temperature by 6°F (Chapin III et al. 2014). Recent climate change effects are having major impacts on Alaska including increased temperatures, reduced sea ice, glacier retreat, thawing permafrost, coastal storms, ocean acidification, floods and drought (NOAA 2013a; Chapin III et al. 2014).

Recent climate model simulations for Alaska used both high and low future global GHG emissions scenarios with sources of climate information considered and approved by the National Climate Assessment Development and Advisory Committee (SNAP 2013). Climate change effects predicted from these scenarios that would most likely affect the Project Area include:

- Predicted increases in the frequency and intensity of storm severity, which may increase flooding and erosion in the Project Area;
- Increased winter and springtime temperatures with increased winter precipitation, which may cause flooding due to increased snowpack or rapid springtime temperature increases;
- Thawing permafrost, which may cause infrastructure damage to roads, utility infrastructure, pipelines and buildings;
- Increased chance of drought during predicted warmer, drier summers, which may limit river transportation and increase the chance or intensity of wildfires.

Within the Project Area, climate change could impact existing barging in the Kuskokwim River that would continue under the No Action Alternative. Predicted air temperature increases due to climate change could result in permafrost degradation where present in the Project Area. Thawing permafrost could cause damage to existing infrastructure, introduce increased carbon dioxide and methane into the atmosphere, and contribute to changes to vegetation and wetlands.

3.26.4.2 ALTERNATIVE 2 – DONLIN GOLD'S PROPOSED ACTION

3.26.4.2.1 ATMOSPHERE

<u>Methodology</u>

As climate change is a global issue, no standard methodology currently exists to assess how a proposed project's GHG emissions would translate into physical effects on the global environment. However, because GHG emissions contribute to impacts on climate change, it is appropriate to analyze GHG emissions when assessing the impacts of a project on climate change (CEQ 2014). In Section 3.8, Air Quality, Table 3.8-18 (Annual Mine Site Operations Phase

Emissions), the Donlin Gold Project mine site could cause direct emissions of up to 1,760,469 tons per year of CO_2-e during operations, which converts to 1,597,070 MT per year. This is above the CEQ guidance threshold of 25,000 MT per year, thus the project warrants a discussion of climate change in the NEPA process (CEQ 2014).

In comparison, the oil and gas industry in Alaska emits a total of about 11,800,000 MT per year; and three large operating mines in Alaska (Greens Creek, Kensington, and Red Dog) each have reported annual GHG emissions in the range of roughly 25,000 to 150,000 MT (Section 3.26.3.1). Direct comparisons between Donlin Gold and other mines is difficult, because existing mines are reporting actual emissions while the Donlin Gold estimates represent worst-case scenario emissions. Regardless, the Donlin Gold mine would emit substantially more GHGs than existing mines, in part because the extraction of gold from the refractory ore at the Donlin deposit is more highly energy intensive than the other mine processes.

There are no precedents or guidelines established for determining the relative magnitude or intensity of GHG emissions; to assess intensity, project GHG emissions are compared to total Alaska GHG emissions (Table 3.26-8). The most recent year of CO_2-e emissions data that is available for the State of Alaska is 2005, when CO_2-e emissions were 52.1 million MT (MMT) (ADEC 2008b). The high level impact level (10 percent of Alaska GHG emissions) is triggered at about 5.2 MMT per year, which is less than 0.1 percent of total U.S. GHG emissions (6,525.6 MMT in 2012), and even less on a global scale, so the impact level is reasonable. (Note: tabulated emission estimates for GHG emissions from the various project phases and components for the Donlin Gold Project were provided in Section 3.8, Air Quality, as tons per year. These are converted to metric tons (MT) per year in this section.)

There is no legislation for GHG emissions at this time. Therefore, the atmosphere is considered common in context due to its global distribution and the global distribution of GHGs for all project components, phases, and alternatives.

Mine Site

Construction

Direct GHG emissions from the heavy equipment required for construction and permafrost destruction would occur during the entirety of construction (3 to 4 years), thus the duration of impacts would be temporary. The intensity of the impact would be considered low because impacts would be less than 1 percent of annual GHG emissions for the state of Alaska. All direct emissions would occur at the mine site; therefore, the geographic extent would be local.

Indirect GHG emissions associated with construction of the mine site would result from activities associated with transporting supplies and construction materials to the mine site. These impacts are discussed under the transportation facilities section below.

Operations and Maintenance

Operations for the mine site would last approximately 27.5 years. Direct GHG emissions would be generated by a dual-fueled (natural gas and diesel) multi-engine power plant, as well as from mobile machinery and the mining equipment necessary for extraction and processing gold throughout the life of the project. Therefore, impacts would be long-term in duration. All activities and impacts would occur at the mine site; the geographic extent would be local for direct emissions of GHGs. The intensity of direct GHG emissions would be considered medium because impacts would be greater than 1 percent of annual GHG emissions for the State of Alaska, but less than 10 percent of annual GHG emissions for the State of Alaska (Table 3.26-9).

Table 3.26-9 shows annual GHG emission from selected other mines in Alaska as reported to EPA under the GHG reporting program, which excludes mobile source emissions; however, GHG emissions from other mine sites are not directly comparable to the Donlin Gold Project as other mines are smaller.

Indirect GHG emissions associated with operations of the mine site would result from emissions associated with transporting supplies and construction materials to the mine site. These impacts are discussed under the transportation facilities section below.

Closure, Reclamation, and Monitoring

To minimize the time needed for reclamation, closure activities would take place in areas that are no longer required for active mining whenever possible during operations. GHG emissions would be generated by the equipment necessary to conduct reclamation activities within the mine site including pit backfilling; stabilizing pit highwalls; regrading, slope contouring and restoration; pumping TSF water to the ACMA pit; covering the tailings impoundment; and building removal. Post-reclamation monitoring activities would continue beyond the 5 year closure timeframe. For example, one small generator would remain at the mine site to operate the post-reclamation water treatment plant until such time the discharge meets water quality standards, and the airstrip would remain permanently. Reclamation and post-reclamation impacts would be long-term in duration, and local in extent. The intensity of direct GHG emissions would be considered low because impacts would be less than 1 percent of annual GHG emissions for the state of Alaska (Table 3.26-9).

Indirect GHG emissions from project-related activities during the closure and reclamation of the mine site may occur due to transportation of supplies and employees to and from the site.

Table 3.26-9: Annual Mine Site GHG Emissions

Project Phase	Project-related CO_2-e Emissions (tpy)	Project-related CO_2-e Emissions (MMT/yr)	Percentage of CO_2-e Emissions for the State of Alaska in 2005[b] (%)	Intensity
Construction	56,342[a]	0.0511	0.098	Low
Operations	1,760,469	1.5971	3.065	Medium
Closure	194,253	0.1762	0.338	Low

Notes:

a The project-related CO_2-e emissions in tons per year are average annual emissions assuming a 3.5 year construction phase.

b Total CO_2-e emissions were 52.1 MMT for the State of Alaska in 2005.

Source: EPA 2014d; Air Sciences 2015b; ADEC 2008b, Cardno 2015b.

Summary of Mine Site Impacts

The intensity of direct GHG emissions from project activities at the mine site would be medium (between 1 percent and 10 percent of Alaska annual GHG emissions). The duration of GHG emissions would range from temporary (construction) to long-term (operations and closure). GHG emissions at the mine site would be local in extent (within immediate Project Area).

Indirect GHG emissions associated with construction and operations of the mine site would result from emissions associated with transporting supplies and construction materials to the mine site. These impacts are discussed under the transportation facilities section below.

Overall, project impacts on climate change would range from minor to moderate for the mine site. The highest GHG emissions represent 0.024 percent of the total U.S. GHG emissions in 2012.

Transportation Facilities

Construction

GHG emissions from fossil fuel combustion would occur from construction equipment, and aircraft, land vehicles and vessels associated with transporting supplies and construction materials to the mine site. Direct emissions would occur at the transportation facilities; therefore, the geographic extent would be local. Direct GHG emissions would occur during the entirety of construction, thus the duration of impacts would be temporary. The intensity of direct GHG emissions would be considered low because impacts would be less than 1 percent of annual GHG emissions for the state of Alaska (Table 3.26-10).

Indirect GHG emissions associated with the transportation facilities construction would result from operations of air traffic between Anchorage (or other points of origin) and the mine site airstrip, and ocean traffic.

Operations and Maintenance

GHG emissions associated with operations of the transportation facilities would result from the combustion of fossil fuels in aircraft, ocean barges, tugs associated with river barges, and tanker trucks delivering diesel. Emissions would occur at the transportation facilities themselves; therefore, the geographic extent would be local. Direct GHG emissions would occur throughout the life of the project, thus impacts would be long-term in duration. The intensity of direct GHG emissions would be considered low because impacts would be less than 1 percent of annual GHG emissions for the state of Alaska (Table 3.26-10).

Indirect GHG emissions associated with operations would result from cruise operations of air traffic between Anchorage (or other points of origin) and the mine site airstrip, and ocean traffic.

Closure, Reclamation, and Monitoring

The mine access road would remain for long-term monitoring of the mine site. Reclamation activities for other transportation facilities would occur during the 5 year period following final mine closure. GHG emissions generated by the equipment necessary to conduct closure, reclamation, and post-reclamation activities would last up to 50 years, so impacts would be long-term in duration. Direct emissions would occur at the transportation facilities; therefore, the geographic extent would be local. Direct GHG emissions were not calculated for this phase, but are expected to be less than operations due to minimal activities and fuel combustion during closure. Therefore, intensity of impacts would be considered low with less than 1 percent of annual GHG emissions for the State of Alaska, as displayed in Table 3.26-10.

No indirect GHG emissions from transportation facilities-related activities are anticipated to occur during closure and reclamation.

Summary of Transportation Facilities Impacts

The intensity of direct GHG emissions from project activities for the transportation facilities would be low, with maximum annual GHG emissions being less than 1 percent of Alaska's GHGs. The duration of GHG emissions would range from temporary (construction) to long-term (operations and closure). Direct GHG emissions at the transportation facilities would be local in extent (within immediate Project Area) (Table 3.26-10).

Table 3.26-10: Annual Transportation Facilities GHG Emissions[a]

Project Phase	Project-related CO_2-e Emissions (tpy)	Project-related CO_2-e Emissions (MMT/yr)	Percentage of CO_2-e Emissions for the State of Alaska in 2005 (%)	Intensity
Construction	312,056	0.2831	0.543	Low
Operations	72,982	0.662	0.127	Low
Closure[b]	nc	nc	nc	Low

Notes:

a Emissions from third party-operated Dutch Harbor Port site are not included. Emissions from the Bethel Port site are considered direct emissions, but they are not included because information is not available.

b GHG emissions during closure were not calculated but are expected to be less than operations.

c Total CO_2-e emissions were 52.1 MMT for the State of Alaska in 2005.

nc = not calculated

Sources: EPA 2014d; Air Sciences 2015b; ADEC 2008b, Cardno 2015c.

Indirect GHG emissions associated with construction and operations would result from cruise operations of air traffic between Anchorage (or other point of origin) and the mine site airstrip, and ocean traffic.

Overall, project impacts on climate change associated with the transportation facilities under Alternative 2 would be considered minor.

Natural Gas Pipeline

Construction

Direct GHG emissions would occur during the 3- to 4-year construction phase and would be temporary in duration. During the first year, activities include ROW clearing and grading of access roads and shoofly roads, preparation of the compressor station site and campsites, camp construction, pipeline storage yards construction, airstrip construction and upgrades, and development of barge landings and material sites. (The Bethel and Angyaruaq [Jungjuk] ports would be used during pipeline construction as well. Impacts from these activities are included under the transportation facilities component.) During Years 2 through 3 or 4, the primary activity would be pipeline installation. Construction-related GHG emissions would be generated by helicopter traffic, diesel-powered mobile equipment, and pipe installation equipment, equipment operating at material sites. GHG emissions would vary depending on the construction stage, and would be localized and transitory as construction activity proceeds at various locations along the length of the pipeline. The intensity of direct GHG emissions would be considered low because impacts would be less than 1 percent of annual GHG emissions for the State of Alaska (Table 3.26-11).

Indirect GHG emissions from project-related activities are anticipated to result from vessels associated with transporting construction equipment and material to the pipeline area.

Operations and Maintenance

The compressor station at MP 5 would be powered by electricity; therefore, it would not have combustion causing GHG emissions. The pipeline components (e.g., compressor station, metering stations, mainline block valves, pipeline) would emit fugitive GHG emissions due to leaks from pipeline segments, valves, and fittings; and from permafrost melting. In addition, there would be project-related maintenance activities that would occur along the pipeline ROW, such as vehicle and helicopter traffic (SRK 2013b). These emissions would be considered local in extent. There would be no vented GHG emissions due to pipeline blowdown for planned maintenance (Rieser 2014a).

The intensity of direct GHG emissions would be considered low because impacts would be less than 1 percent of annual GHG emissions for the State of Alaska (Table 3.26-11).

Indirect emissions would occur at the Beluga Power Plant that would be used to supply power for the compressor station at MP 5.

Closure, Reclamation, and Monitoring

Direct GHG emissions during closure and reclamation of the pipeline would result from small hand tools used to cut aboveground sections of the pipeline, would last less than 4 years, and are considered temporary in duration and local in extent. Maximum direct GHG emissions are expected to be much lower than during construction and operations.

No indirect GHG emissions from project-related activities are anticipated to occur along the pipeline during closure.

Summary of Natural Gas Pipeline Impacts

The intensity of direct GHG emissions from the pipeline would be low, with maximum annual GHG emission being less than 1 percent of Alaska's GHGs. The duration of GHG emissions would range from temporary (construction) to long-term (operations and closure) (Table 3.26-11).

Table 3.26-11: Annual Pipeline GHG Emissions[a]

Project Phase	Project-related CO_2-e Emissions (tpy)	Project-related CO_2-e Emissions (MMT/Yr)	Percentage of CO_2-e Emissions for the State of Alaska in 2005[c]	Intensity
Construction	258,746	0.2347	0.451	Low
Operations	10,036	0.0091	0.000	Low
Closure	nc	nc	nc	Low

Notes:

a Does not include indirect emissions associated with electrical demand of the compressor station at MP 5 during operation and maintenance activities.
b GHG emissions during closure were not calculated but would be expected to be less than operations.
c Total CO_2-e emissions were 52.1 MMT for the State of Alaska in 2005.

nc = not calculated

Source: EPA 2014d; Air Sciences 2015b; ADEC 2008b, Cardno 2015e.

Overall, impacts of GHG emissions from the pipeline on climate change under Alternative 2 would be considered negligible to minor.

<u>Summary of Impacts for Alternative 2 – Atmosphere</u>

The magnitude of GHG emissions during construction, operations, and closure of all components of this project would be considered low to medium, representing at most 0.024 percent of U.S. total GHG emissions in 2012 (EPA 2014d). The maximum duration of impacts would be long-term, with GHG emissions occurring throughout the duration of the project. Direct GHG emissions would be local in extent (occurring in Project Area) and context is common. Therefore, the Donlin Gold Project would cause minor impacts to climate change under Alternative 2.

3.26.4.2.2 WATER

This section analyzes how climate change could affect project impacts on water flow, including incremental effects that climate change would have on base case impacts identified in Sections 3.5, Surface Water Hydrology, and Section 3.6, Groundwater Hydrology. Key indicators include predicted precipitation changes due to climate trends and consequent changes in project impacts to streamflow and groundwater recharge, and the implications of these changes on project plans, facility designs, and related risks to the environment.

The criteria for evaluating the levels of effects in this section are generally the same as those presented in Section 3.5, Surface Water Hydrology, Table 3.5-24, as applied to the incremental effects of climate change on project impacts to water flow. For example, low magnitude effects could include climate-caused changes in water flow that are within historical seasonal variation and that require no change in water management strategies at the mine or operational rules for barging on the Kuskokwim River. Medium magnitude effects could include changes in water flow outside of historic variation that would require changes in operational rules, although hydraulic designs of major structures would still be adequate for conditions.

The context of climate change effects on water resources for all project components is considered common to important. While climate change is a wide-ranging global phenomenon, and water is an abundant resource, water is shared with other resources, and its use and related structure design is governed by regulation.

Mine Site

Construction, and Operations and Maintenance

The effect of climate change on precipitation and hydrology at the mine site has implications for infrastructure design and the capacity of major mine facilities to handle different water regimes under future climate change scenarios. The approach taken at the mine site with respect to hydrologic design is generally consistent with the U.S. Global Change Research Program (Bierbaum et al. 2014) and NOAA (2015b) guidance for adaptation based on identification of climate change vulnerabilities, risks, and options.

Effects on TSF. A 25 percent increase in annual precipitation was selected to represent the effects of climate change on the TSF during operations in sensitivity runs on the mine site water balance model (BGC 2011g, 2014b; Weglinski 2015b). The 25 percent increase case is considered conservative in that the SNAP data predicts much less than this (2 percent increase) for the life of the mine, and the TSF would be closed and capped by the time of the predicted 25 percent climate change increase. A stochastic model was used for the sensitivity analysis, which allows calculation of the probability of a particular outcome to quantify risk. The results indicated that, prior to development of the advanced water treatment (AWT) scenario, a 25 percent precipitation increase would result in an average annual water storage requirement in the TSF impoundment roughly three times that of the base case (71,000 acre-feet vs. 24,000 acre-feet, respectively) or as much as 91,000 acre-feet for the 95th percentile probability value. These volumes are well within the ultimate design capacity of the TSF impoundment of 357,000 acre-feet, which accounts for the combined volume of tailings, pond, and flood storage (BGC 2014b). With AWT, the effects of a 25 percent increase in precipitation would be within the range of effects for the original Alternative 2 analysis (Weglinski 2015b), as the TSF would be designed to the same capacity but contain less process water. Based on ratings criteria in Table 3.5-24 (Section 3.5, Surface Water Hydrology), the estimated magnitude of climate change effects are expected to be low, in that adverse impacts from the added effects of climate change are unlikely because the TSF design would be adequate for predicted conditions, and mine site water management would be flexible enough to accommodate the extra dewatering water from potential climate change precipitation increases.

Effects on Pit Dewatering and Freshwater Requirements. The AWT proposed under Alternative 2 for treating and discharging pit dewatering water and other contact water is expected to provide maximum flexibility in overall water management, which would be useful in the event of increased precipitation due to climate change over the life of the mine. The 25 percent precipitation increase described above for the TSF was also used in water balance sensitivity runs to estimate the effect of climate change on the volume of pit dewatering water under Alternative 2. The results indicate that total dewatering volume during operations would increase by approximately 5,000 acre-feet (an average increase of about 200 acre-feet annually) in the event of a 25 percent precipitation increase (BGC 2014b). The 25 percent precipitation increase case also results in a reduction in total freshwater requirements from Snow Gulch reservoir from about 3,400 to 400 acre-feet (a decrease of about 120 acre-feet annually), because there would be more dewatering and mine contact water available to meet process water needs. The AWT water treatment plant would be designed for an average flow of about 2,900 acre-feet/year, and a maximum of 4,400 acre-feet/year, which is about 50 percent or 1,500 acre-feet/year above the average and could be expanded if necessary (Hatch 2015). Thus, mine site water management under the AWT scenario would be able to accommodate extra dewatering water from potential climate change precipitation increases through flexibility in WTP design and less freshwater use.

Extreme Events. Uncertainties inherent in applying climate change trends to the effects analysis of the proposed action are discussed in the above Section 3.26.3.2, Climate Change, Water Resources. An important modeling objective is to determine the potential impact of extreme events on engineered structures, as these events tend to drive facility designs more than monthly or annual average changes that are derived from climate models. There are conflicting results from different research with regard to the impact of climate change on rare events such as are used to design spillways. A recent NOAA study in Alaska (Perica et al. 2012) indicated no statistically significant trends in the 1-hour and 1-day annual maximum series. Although there is evidence that average annual precipitation would increase as a result of climate change in the next 30 years, Perica et al. (2012) found no evidence that the magnitude and frequency of rare events is changing. Other studies suggest that the number of very heavy precipitation events (i.e., defined as those that comprise 1 percent of all daily events) have increased about 5 to 11 percent since 1980, and that their frequency will continue to increase in the future (Walsh et al. 2014).

The effects of extreme precipitation events and both wetter and drier climates on facilities at the mine site have been evaluated through application of low probability events based on local historic records from the 1950s to present. As described in Section 3.5, Surface Water Hydrology, major water containment structures at the mine site have been designed in accordance with ADNR (2005) Dam Safety Guidelines that prescribe the use of certain maximum runoff events for the inflow design flood (IDF) depending on dam hazard rating. For example, these include the 24-hour probable maximum precipitation plus 200-year snowmelt for Class I facilities like the TSF dam, and the 24-hr probable maximum precipitation including snowmelt for Class II structures like some water dams at the mine site; and 3 days of underdrain flow plus the 200-year, 24-hour rainfall event for the SRS pond and wells (BGC 2011a). In addition, a mitigation recommendation is provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation), to incorporate a potentially longer-term event (time of concentration) into final design of major structures at the mine. This would ensure that the maximum rainfall event used for the IDF design is adequate, and reduce the likelihood that an extreme event lasting longer than 24 hours could cause overtopping, erosion, and/or and a release of impaired water quality to the environment.

In addition to the design of major structures, BGC (2014b, 2015f) assessed precipitation and runoff effects, based on 30-year historical trends, for the 10th and 90th percentiles of the precipitation distribution to evaluate significantly drier and wetter than average conditions for the purpose of determining overall water management strategies at the mine site. Individual years within the historic datasets can exhibit annual precipitation that fluctuates 40 percent above and below the average. These ranges are significantly greater than the trends in average annual precipitation predicted by SNAP data over the life of the mine (2 percent increase).

Water balance models were developed for the mine site based on these trends for both above-average and below-average conditions, and for different phases (operations and closure). The results were used to develop a set of operational rules or strategies for the mine site to handle the large range of expected conditions (see Section 3.5, Surface Water Hydrology). As mine operations proceed, water balance models and sensitivity analyses are typically updated based on a longer period of record, and facility designs or operational strategies are modified to handle changes in precipitation predictions. For example, additional capacity could be added to the SRS or the schedule for tailings dam raises altered if wetter years are predicted, or more Snow Gulch reservoir water or dewatering water could be reserved for processing if drier trends are predicted.

Thus, impacts are anticipated to be of low magnitude during mine construction and operations, in that incremental effects due to climate change are unlikely because current designs and water balance planning account for wide historic ranges that are greater than predicted precipitation trends during the life of the mine.

Closure, Reclamation, and Monitoring

As described in Section 3.6 (Groundwater Hydrology), the effect of a wet climate scenario was evaluated in sensitivity runs on the mine groundwater model for the purpose of analyzing effects on pit lake filling rates (BGC 2014c). By increasing groundwater recharge and streamflows by a factor of two, the pit lake was calculated to fill in 30 years, as compared to the base case of 60 years. As the pit lake fills, the water level would be monitored and the pit lake model would be recalibrated as data become available (SRK 2012d). The effect of fill rate on water management of freeboard at the pit lake in post-closure is discussed in Section 3.5, Surface Water Hydrology. The managed maximum lake stage would be approximately 33 feet below the lowest point on the pit rim. In the event of pump failure, a faster fill rate could mean that the lake would reach the spill point in 2 to 3 years, as compared to 5 to 7 years for the base case. Because 2 to 3 years is adequate time to fix potential equipment problems, the likelihood of potential overflow of contaminated pit lake water to Crooked Creek is considered low to medium, in that the freeboard (the difference between the managed stage and the spill point) is adequate for expected conditions, even under a wet climate scenario, although water treatment strategies may need to be reassessed to accommodate a potentially faster fill rate. Additional mitigation recommendations are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation) for reassessing the effect of climate change on water balance and groundwater models in post-closure approximately every 10 years in order to adequately anticipate effects on pit filling and other project structures.

Summary of Mine Site Impacts

Climate change effects on the impacts that major structures and water management at the mine site have on water flow are expected to be of low intensity during the mine life and of low to medium intensity during post-closure; in that climate effects may or may not be discernable beyond extremes predicted by the historical record, hydrologic designs meet or exceed state guidelines and would be adequate to accommodate climate change effects, and water management and treatment strategies are flexible enough to accommodate potential long-term precipitation trends. This analysis is based partly on state and global studies that do not exhibit confident trends in rare events, and on infrastructure designs that appear robust enough to accommodate modest increments in rare events that may be caused by climate change outside of extremes already predicted by the historical data. The duration of climate change effects would be long-term to permanent, as these effects are not expected to cease within the life of the mine or post-closure. The geographic extent of effects would range from local to regional, in that some hydrologic effects would be limited to within mine site boundaries (e.g., small water diversion structures) and some could affect Crooked Creek beyond the mine site (e.g., pit dewatering reducing winter flow) with or without climate change effects. Overall effects of climate change on water impacts at the mine site are considered minor to moderate.

Transportation Facilities

Barging

The effect of climate change on precipitation could impact barging in the Kuskokwim River during construction and operations. Predicted precipitation changes along the river are based on SNAP precipitation data from several river communities (Figure 3.26-1, Table 3.26-12). The relationship between precipitation and change in discharge is a complex issue, and a difficult one to translate to effects on barging. A simplistic model was developed to predict the order of magnitude of the effect that climate change is likely to have on proposed barging activities.

Methodology for Estimating Available Barging Days. Based on assuming a direct and proportional response between precipitation and discharge, SNAP precipitation predictions were applied to Kuskokwim River discharge data in order to evaluate the effect of potential summer month decreases on water flow and available barging days in the Kuskokwim River (URS 2014). A series of computations were conducted on 60 years of Kuskokwim River discharge data collected at the USGS Crooked Creek gauge (USGS 2014b) to evaluate the likelihood that the proposed number of barging days (110) under Alternative 2 would be available (AMEC 2014). The computations initially counted available barge days and their probability of occurrence over the period of record under three base case scenarios: 1) the total number of days in each of the 60 years of record that exceeded a minimum discharge of 39,000 cfs needed to operate between Nelson Island and the Angyaruaq (Jungjuk) Port (AMEC 2014; Enos 2014); 2) the number of days greater than 39,000 cfs within the proposed 110-day shipping season between June 1 and September 18 (AMEC 2014); and 3) the number of days constrained by estimated dates of breakup and freezeup available from the National Weather Service (2014).

The discharge record was then reduced based on the monthly SNAP data to represent a possible future climate change discharge record (Table 3.26-13). The average of the monthly precipitation changes for the communities of Crooked Creek, Sleetmute, and McGrath for the decade 2040-2049 were selected to represent the effects of climate change on future flow conditions in the Kuskokwim River transportation corridor, as precipitation happening in these communities and the surrounding hills is considered most likely to contribute to discharge conditions below Crooked Creek. For months in which the mean monthly precipitation at the villages is predicted to increase, no change was made to the daily discharge record. However, it was assumed that the daily discharge associated with each year of record would decrease by the same percentage as the mean monthly precipitation at the village.

Table 3.26-12: Average Monthly Precipitation Change Applied to Kuskokwim River Discharge Record

Month	Predicted Average Monthly Precipitation Change for Crooked Creek, Sleetmute, and McGrath[1] (%)	Average Monthly Precipitation Change Applied to Kuskokwim River Daily Discharge Record (%)
April	+10.6	0
May	+2.0	0
June	-3.3	-3.3
July	-10.6	-10.6
August	+1.7	0
September	-3.2	-3.2
October	+15.4	0

Notes:

1 Average of 3 communities' predicted change in precipitation for decade 2040-2049.

Source: SNAP 2012.

Results of Available Barge Days Analysis. The results of the discharge computations for both the base case scenarios and the scenario with reductions due to climate change are shown in Table 3.26-13. The climate change case indicates that the median number of days a barge could operate is 140 per year. In 9 out of 10 years, barges could operate for at least 113 days, and in none of the 60 years of record would the available days be less than 95.

Table 3.26-13: Available Barge Days on Kuskokwim River under Base Case and Climate Change Scenarios

Probability of Occurrence[1] (%)	Base Case Scenarios[2]			Climate Change Scenario[2]
	#1: All Available Days ≥39,000 cfs[3] (Jan. 1-Dec. 31)	#2: Available Days ≥39,000 cfs within June 1-Sept. 18 Shipping Season[4]	#3: Available Days within Breakup and Freezeup[5]	#4: Available Days ≥39,000 cfs after Reducing Discharge by SNAP Precipitation Predictions[6]
10	184	110	153	153
20	173	110	152	148
30	168	110	146	145
40	167	110	143	141
50	163	110	141	140
60	159	110	139	137
70	151	110	135	131
80	146	104	127	125

Table 3.26-13: Available Barge Days on Kuskokwim River under Base Case and Climate Change Scenarios

Probability of Occurrence[1] (%)	Base Case Scenarios[2]			Climate Change Scenario[2]
	#1: All Available Days ≥39,000 cfs[3] (Jan. 1-Dec. 31)	#2: Available Days ≥39,000 cfs within June 1-Sept. 18 Shipping Season[4]	#3: Available Days within Breakup and Freezeup[5]	#4: Available Days ≥39,000 cfs after Reducing Discharge by SNAP Precipitation Predictions[6]
90	135	93	121	113
Maximum No. of Days	197	110	171	171
Average No. of Days	160	106	138	136
Minimum No. of Days	110	73	96	95

Notes:

1 Percentage of years in which number of days is equal to or greater than value presented.
2 Based on 60-year discharge record at Kuskokwim River-Crooked Creek gage (USGS 2014b). The years 1951, 1994, and 1995 have only partial records with some data missing for potential barging months; thus, they have not been used in the analyses.
3 Conservative minimum discharge reading at Kuskokwim River-Crooked Creek gage needed to operate between Nelson Island and the Angyaruaq (Jungjuk) Port (AMEC 2014; Enos 2014).
4 Proposed by Donlin Gold (AMEC 2014).
5 Estimated based on NWS (2014) dates for breakup, first boat, last boat, and freezeup.
6 Based on average monthly precipitation reductions shown in Table 3.26-12 (SNAP 2012), and applying same monthly reduction to each day of record within month.

cfs = cubic feet per second

Source: URS 2014c.

The results suggest that even with a change in precipitation similar to what the SNAP estimates suggest, the number of days available for barging would not be outside the range considered by Donlin Gold in developing the barge plan for the proposed project. Though measureable, the change in number of days available as a result of climate change appears to be minor compared to the year-to-year variability. In addition, the analysis conservatively does not account for increases in flow predicted for certain months by the SNAP data (e.g., May and August).

Because the results of the climate change scenario are based on potential use of all days between breakup and freezeup, low water years could require an adjustment in the dates of operation to earlier in spring or later in the fall than assumed under base case Scenario #2 (June 1 to Sept. 18 shipping season). This is considered part of the proposed action as one possible method of increasing the amount of supplies that can be barged in a year (AMEC 2014). Additional proposed mitigations and contingencies for low water conditions are described in Section 3.5, Surface Water Hydrology, and are included in Chapter 5, Impact Avoidance, Minimization, and Mitigation). These include collection of daily and real-time barge draft data for forecasting river depths, storage of sufficient inventory at the mine and Bethel as backup for reduced barging days, chartering a third tow, operating with reduced under keel clearance, and implementation of a stranded barge plan if needed (AMEC 2014; Donlin Gold 2013e). These measures are expected to be effective in minimizing the potential effect of low water years on barge stranding risk and mine shipping needs.

Mine Access Road

The effect of climate change on precipitation has potential implications for the capacity of culverts and bridges along the mine access road to handle breakup flow and high precipitation events during the life of the mine as well as the post-closure period. Donlin Gold is considering replacing some culverts along the Jungjuk Road at closure with low water crossings, due to the anticipated low level of use and monitoring in post-closure (Chapter 5, Impact Avoidance, Minimization, and Mitigation) (Midnight Sun Court Reporters 2015). Predicted climate change effects on precipitation in the vicinity of the mine access road are similar to those predicted for the mine site and the other Kuskokwim River drainages described above (Table 3.26-4); these include an overall increase in annual precipitation, with lower summer precipitation balanced by higher precipitation in fall and winter months, which could result in greater snowmelt during breakup. However, as described above under Mine Site, recent studies are conflicting as to the prediction of statistically significant trends in rare precipitation events in Alaska due to climate change (e.g., Perica et al. 2012; Walsh et al. 2014). Because rare events are typically used to design culverts and bridges, and because the culverts may be replaced with low water crossings, the effect of climate change on their design is expected to be low, in that the added effects of climate change may or may not be noticeable, and the design is anticipated to be adequate for the conditions.

Summary of Transportation Facilities Impacts

Potential climate change effects on transportation facilities with respect to water flow are expected to be of low intensity during mine life, in that effects may or may not be noticeable. Sufficient barge days would be available even under a climate change scenario to meet proposed shipping needs without increased risk of barge stranding, and the barge plan and proposed contingencies are expected to be adequate to accommodate predicted climate change trends during operations. In addition, effects would be of low intensity in post-closure for the mine access road where culverts are replaced with low water crossings. Effects may be of low to medium magnitude for facilities that remain in post-closure such as culverts and bridges that could experience the longer-term trends of increased precipitation. The duration of climate change effects would be long-term to permanent, with potential impacts lasting throughout barging operations and use of the road throughout post-closure. While the extent of climate change effects is global, the extent of project effects would be considered local to regional, as they could be limited to critical sections of the Kuskokwim River or certain road drainages, but may involve potential contingencies that could extend from Bethel to the mine site. The context of climate change effects on transportation water resources is considered common to important; while climate change is a wide-ranging global phenomenon and water in the Kuskokwim River is an abundant resource, the river flow is shared with other users and other river traffic is important to the welfare of river communities. Overall effects of climate change on the transportation facilities associated with Alternative 2 are considered minor.

<u>Natural Gas Pipeline</u>

Climate change effects on precipitation during pipeline operations could cause changes in erosion patterns along the cleared ROW and scour potential at waterbody crossings. Average annual precipitation in Cook Inlet basin, Alaska Range, and Kuskokwim Hills is anticipated to increase on the order of 2 to 15 percent over the life of the project as a result of climate change (SNAP 2012), with the higher increases in the Alaska Range and lower increases in the

Kuskokwim Hills. Most of the increased precipitation in Cook Inlet basin is predicted to occur in winter months and during breakup, although the winter increases could occur as rain, resulting in a reduced snowpack with smaller intermittent melting episodes, rather than a large breakup. Effects from increased snowmelt and precipitation at breakup represent potentially worse effects on the pipeline (such as scour) than intermittent snowmelt.

Greater discharge at breakup could cause increased risk of bank erosion and scour along major river crossings, e.g., in areas of known river erosion along the Jones and South Fork Kuskokwim rivers (Figure 3.3-4, Section 3.3, Geohazards and Seismic Conditions) and at other major rivers draining the Alaska Range and Kuskokwim Hills (Figure 3.5-15, Section 3.5, Surface Water Hydrology). While the duration of scour effects on the integrity of the pipeline would be long-term, lasting through the life of the project, the abandoned-in-place pipeline in post-closure could also cause increased bed or bank erosion locally if exposed.

At HDD river crossings, the pipeline would be installed well below (typically 10s or 100s of feet below) any river scour hazard, and the ends of the HDD segments would be set back from the riverbanks at distances ranging from 400 to 3,900 feet (Section 3.2, Soils). Typical burial depths at other stream crossings would be 4 feet, except at river crossings with high scour potential, where the pipeline would be buried up to 10 feet below the thalweg (SRK 2013b). Thalweg depths have been determined based on site-specific calculations of the 100-year event scour depth at each crossing (CH2M Hill 2011c). In addition, the length of increased cover depth along river crossings assumes that active channels could move anywhere within historic floodplains.

Additional geotechnical investigation would be conducted prior to final design (e.g., Section 3.2, Soils) to evaluate site-specific conditions for PHMSA permitting. The magnitude of the effects from climate change potentially causing increased scour at breakup is anticipated to be mostly low, in that the depth of cover designed for the 100-year event would be within the limits of historical variation, although these conditions could plausibly be exceeded in post-closure in the event of precipitation increases due to climate change, leading to occasional medium intensity effects. Additional mitigation recommendations are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation) to address monitoring and rehabilitation in post-closure that could reduce effects to low intensity levels.

Potential increased precipitation and discharge at breakup could also cause erosion along the cleared ROW. The magnitude of these effects is anticipated to be low in late operations, as revegetation during reclamation immediately following construction is expected to stabilize early in the operations period.

Increased precipitation and breakup discharge could cause an increase in the occurrence of glaciation or aufeis effects at co-located ROW and Iditarod National Historic Trail (INHT) segments between MP 84 and MP 97. As described in Section 3.2, Soils, localized glaciation (usually extending less than 1/4 mile along the trail) is known to occur along the trail in the Alaska Range in winter, and can accumulate about 1 to 10 feet thickness of solid ice (BLM 2015d), a situation which could be exacerbated by the co-located pipeline ROW and be hazardous for trail users due to slippery cross slopes associated with the flowage. Best management practices (BMPs) and erosion and sedimentation control (ESC) measures emplaced to promote non-erosive drainage from existing and new water sources and pathways, and regular monitoring and maintenance during operations (Section 3.2, Soils), are expected to minimize these effects along the ROW and co-located INHT sections and crossings.

Summary of Natural Gas Pipeline Impacts

The magnitude of potential climate change effects on pipeline impacts to water would range from low during the mine life, to a range of low to medium during post-closure, in that the effect of climate change on ROW erosion in operations would be mitigated by revegetation and stabilization early in operations, and most scour hazards at river crossings would be mitigated by designing for the 100-year flood. The duration of climate change effects on the pipeline would be long-term to permanent, with potential impacts on the integrity of the pipeline lasting through the life of the project, and local erosion effects from a potentially exposed pipeline continuing into post-closure. While the extent of climate change effects is regional to global, the extent of project effects would be considered local, as erosion and scour impacts would be limited to the immediate vicinity of the pipeline corridor. The context of climate change effects on water is considered common to important: while climate change is a wide-ranging global phenomenon and water in the pipeline region is an abundant resource, the effects of erosion and scour hazards are governed by regulation. Overall, direct and indirect effects of climate change on water impacts along the pipeline are considered minor to moderate overall.

Summary of Impacts for Alternative 2 – Water

Hydrologic effects due to climate change at the mine site, transportation facilities, and natural gas pipeline under Alternative 2 would range from low intensity (e.g., sufficient barge days would be available under a low water climate change scenario to meet proposed shipping needs) to medium intensity (e.g., a faster pit lake filling rate could require changes in water management/treatment strategies in post-closure). The duration of climate change effects would be long-term to permanent, with potential impacts lasting through the life of the project (transportation and pipeline components) and in post-closure (mine site). The extent of project effects would be considered local to regional. The context of climate change effects on water as pertains to the project is considered common to important. Overall effects for water resources are considered minor to moderate.

3.26.4.2.3 PERMAFROST

Mine Site

Mine site permafrost is discussed extensively in Section 3.2, Soils. Mine site effects on permafrost in the absence of climate change, and the types of permafrost-related hazards that could impact the project in the absence of climate change and the proposed design features that could mitigate these hazards, are described in Section 3.2, Soils. These include thaw settlement where soils are removed to construct roads and mine site infrastructure; excavation of most permafrost soils at dams and the toe of the WRF to improve foundation conditions; excavation of upper permafrost soils beneath the tailings impoundment to reduce differential thaw settlement; and berms and collection ponds at overburden stockpiles to capture sediment flow from melting permafrost soils. In addition, permafrost degradation at the mine site could cause a release of trapped carbon into the atmosphere. Estimates of GHG emissions from both permafrost degradation and drying of wetlands soils from pit dewatering are discussed in Section 3.8, Air Quality.

Regional climate change trends suggest that northward expansion of permafrost thaw would occur, and that ground temperatures in the mine site area could increase by roughly 1.5°F to 2°F over the life of the mine (Markon et al. 2012), potentially thawing already warm permafrost in the mine region to more than 32°F. However, changes in soil cover at the mine site would have a comparably greater effect on permafrost thaw than climate change, as removal or disturbance of soils in most areas of the mine site are expected to accelerate thaw much faster than climate change would on undisturbed soils. Small areas of the mine site where soils are left in place, or compacted but not removed, could experience some additional thaw degradation and settlement during mine operations due to climate change, but these areas comprise a small percentage of the total area where soils are completely removed or covered. In areas where permafrost soils are not removed but are covered by project facilities (e.g., overburden piles), climate change is expected to have little effect on increasing the rate of permafrost thaw, due to the insulating effect of the added ground cover material. Areas of the mine site with coarse-grained surficial deposits (e.g., Crooked Creek terrace gravels) would not experience much thaw settlement regardless of whether thaw is caused by soil removal or climate change. Thus, the incremental effect of climate change on permafrost at the mine site would be small, and impact ratings would be similar to those of Alternative 2 in the absence of climate change, as described below.

Summary of Mine Site Impacts

Climate change effects on permafrost impacts would range from low intensity (e.g., little noticeable additional ground settlement from climate change in areas of coarse-grained deposits) to medium intensity (e.g., design and excavation of permafrost soils beneath major structures is adequate to mitigate potential thaw hazards). As in the base case (i.e., no contribution from climate change), specific low probability permafrost conditions may exist that could cause medium to high intensity effects (e.g., at the toe of the WRF) that could be reduced through additional mitigation (e.g., Chapter 5, Impact Avoidance, Minimization, and Mitigation). In post-closure, effects would be of lower intensity due to reclamation preserving remaining permafrost, although climate change would result in less permafrost preservation than the base case. While climate change effects on permafrost would be extended, with effects reaching beyond the Project Area, Project–related effects on climate-altered permafrost would be localized beneath facility footprints and cleared areas. Permafrost thaw effects would range from long-term (e.g., unstable foundations reach equilibrium within life of mine) to permanent (i.e., restoration of permafrost not expected). Discontinuous permafrost and climate change are considered common in context based on their regional to global distribution. Overall direct and indirect effects would range from minor to moderate.

Transportation Facilities

The occurrence of discontinuous permafrost along the mine access road and Angyaruaq (Jungjuk) and Bethel ports is discussed in Section 3.2 (Soils). The types of effects that the transportation facilities could have on permafrost in the absence of climate change, and the types of permafrost-related hazards that could impact these project facilities in the absence of climate change and the proposed design features that could mitigate the hazards, are also described in Section 3.2 (Soils). These effects include differential thaw settlement along the road and at the ports, use of geotextile material to mitigate permafrost road sections, and thawing of permafrost soils in the Jungjuk waste soil stockpile.

Regional climate change trends predict that ground temperatures in the area from Bethel to the mine site could increase by roughly 1.5°F to 3.5°F over the life of the mine (Markon et al. 2012), potentially thawing already warm permafrost in the area. However, removal of soils during construction at these facilities, and possible excavation of permafrost to mitigate the effects of differential settlement on structures (e.g., docks, tanks), would have a comparably greater effect on permafrost thaw than climate change, as disturbance of soils in most areas of the road and ports are expected to accelerate thaw much faster than climate change would on undisturbed soils, and excavation would permanently remove permafrost soils to depths that would probably be beyond the effects of accelerated thawing from future warming. In areas where permafrost soils are not removed but are covered by project facilities (e.g., geotextile and fill along road), climate change is expected to have little effect on increasing the rate of permafrost thaw or causing increased differential settlement, due to the insulating and strength effects of the added material.

Summary of Transportation Facilities Impacts

Permafrost impacts at transportation facilities due to climate change would range from low intensity (e.g., little noticeable additional ground settlement from climate change) to medium intensity (e.g., erosion/sedimentation of thawing soils in port stockpile with or without climate change). Like the base case (i.e., no contribution from climate change), these effects would likely be reduced to low intensity through planned special design and additional mitigation. While climate change effects on permafrost would be extended, with effects reaching beyond the Project Area, project–related effects on climate-altered permafrost would be localized beneath facility footprints and cleared areas. Regardless of climate change, most permafrost thaw effects would range from long-term (e.g., road conditions reach equilibrium within several years) to permanent (i.e., restoration of permafrost not expected). Discontinuous permafrost and climate change are considered common in context based on their regional to global distribution. Overall direct and indirect effects would range from minor to moderate.

<u>Natural Gas Pipeline</u>

The occurrence of discontinuous permafrost along the pipeline is discussed in Section 3.2, Soils. The types of effects that the pipeline could have on permafrost in the absence of climate change, and the types of permafrost-related hazards that could impact these project facilities in the absence of climate change and proposed design features that could mitigate the hazards, are also described Section 3.2, Soils. These include differential thaw settlement along the trench at transition points between thaw unstable permafrost and either thaw stable permafrost or soils with no permafrost; strain-based design of the pipe to allow for flexibility, pipe construction features, and strain monitoring methods to mitigate differential settlement; thermal erosion of the cleared ROW or cuts in thaw unstable soils; and BMPs and ESC measures to mitigate thermal erosion.

Regional climate change trends predict that ground temperatures along the pipeline corridor could increase by 0°F to 3.5°F over the life of the mine (Markon et al. 2012), potentially thawing already warm permafrost in the pipeline region. Pipeline thermal modeling was performed by CH2M Hill (2011a, b) and Zarling (2011), and updated by Fueg (2014), to evaluate thaw settlement effects in response to the buried thermal regime. Methodology, models, and assumptions are described in Section 3.2, Soils. The models were run as (1) a base case using historical annual temperatures from Farewell Lake and (2) as climate change cases for both a 30-year mine operations period and a 75-year post-closure period. The modeled climate change cases assume a mean annual temperature increase over time of 0.04°F/year (or 4°F/100 years) due to global climate change, which is consistent with temperature trends in McGrath over the past 36 years and the lower range of predicted statewide air temperature increases from climate change models.

Clearing of ROW vegetation during construction and maintenance, which initiates permafrost degradation and continues to contribute to thawing over time, would be the same in both the base case and climate change cases. Likewise, the lateral extent of permafrost degradation would be the same in both cases, coinciding with the extent of permafrost covering about 60 miles of the pipeline route and occurring intermittently between about MP 100 and MP 215, but the amount of degradation and vertical thaw settlement would be more for the climate change case. Initial analyses (CH2M Hill 2011a, b; Zarling 2011) yielded predicted thaw depths beneath the disturbed ROW and trench of 8 to 33 feet for the 30-year climate warming case, which represents a 4-foot increase in thaw depth due to climate change over the mine life. Based on the updated modeling results (Fueg 2014), thaw depth predictions in the climate change case were 30 feet for the operations period and 50 feet for the ROW after 75 years (roughly 45 years into post-closure), which represent increases of 3 to 13 feet of thaw depth over that of the base case (i.e., no contribution from climate change).

Permafrost soils can act as a source of carbon dioxide and methane emitted to the atmosphere when thawed. The total amount of soils along the pipeline that are predicted to thaw during operations and closure assuming no contribution from climate change is roughly 37 million tons. Based on the incremental depths of thaw predicted for the climate change case and the same soil density and ROW width assumptions used in the base case, an additional 9 million tons of permafrost soil are predicted to thaw during operations and closure.

The amount of ground settlement associated with the above thaw depth predictions ranges from 0 to 23.5 feet during operations and up to 43 feet in post-closure, which represent increases in the range of 0 to 13 feet above the base case due to climate change. As described in Section 3.2, Soils, boreholes with the highest predicted settlements due to climate change are located in the Alaska Range along the Threemile Creek/ Jones River portion of the alignment near MPs 115 to 120. This is an area with additional geohazards such as landslides where specialized construction techniques (e.g., HDD or deep bedrock trenching) are proposed that would also address concerns about thaw settlement by drilling beneath or removing permafrost-bearing overburden (Fueg 2014). Thus, the primary area of concern for thaw settlement would be on the north side of the Alaska Range between the North Fork Kuskokwim River (MP 147) and the main stem Kuskokwim River (MP 240). About 37 percent of geoprobe holes in this area contain permafrost, with thaw settlement estimates ranging from 0.2 to 7.3 feet at ground surface during operations, and 0.2 to 8.6 feet in post-closure, which represent increases in the range of 0 to 2 feet above the base case due to climate change. Thus, the effect of climate change on permafrost along the pipeline is expected to be measurable (medium intensity) but small compared to thaw settlement caused by ROW clearing in the absence of climate change, as vegetation removal during construction and ROW maintenance contributes the most to permafrost degradation.

These percentages and settlement estimates are considered conservative. The geoprobes specifically targeted areas of suspected ice-rich permafrost. Probes which were unable to penetrate material at depths shallower than the estimated thaw depth were assumed in the model to continue with the final soil layer logged, even though a probe unable to penetrate something other than frozen soils (such as boulders or bedrock) would be less likely to contain deep permafrost.

As described in Section 3.2, Soils, the effects of differential settlement on pipeline integrity would be addressed through PHMSA Special Permit conditions. Conditions specific to the operations period could include, for example, in-line tool inspections, strain gauges in problematic segments, and frequency of PHMSA permit reviews.

The unmitigated effects of ground settlement and thermal erosion during operations could lead to adverse changes in drainage patterns and erosion. Mitigation for these effects would be addressed primarily during construction by placing a mound of fill over the trench to allow for settlement, and by employing BMPs and an Erosion Sediment Control plan measures in permafrost areas of the ROW as described in Section 3.2, Soils. In addition, some erosion stabilization would occur over time due to revegetation regardless of ground settlement, although scattered locations along the north side of the Alaska Range could experience settlement-related drainage channeling and erosion. These areas would be addressed through routine monitoring and ROW maintenance during operations. Additional fill may be required in some areas on an ongoing basis through proactive monitoring and maintenance. These actions are expected to reduce the effects to a low to medium intensity.

The magnitude of climate change effects on thermal erosion in post-closure is expected to be mostly of low to medium intensity for similar reasons. The amount of additional ground settlement that is predicted to occur along the north side of the Alaska Range in post-closure due to climate change is predicted to be in the range of 0 to 3.4 feet beyond that of the operations period (Fueg 2014), which could lead to occasional high intensity erosion effects if unmitigated. These effects are expected to be partly mitigated through a revised SRR Plan compiled specifically for termination and reclamation, which may include visual overflight monitoring and placement of additional fill and/or other erosion control measures as needed (SRK 2013b). The SRR Plan would not necessarily cover the post-closure period, however, and mitigation recommendations are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation), for consideration of additional bonding that would allow continuation of monitoring and stabilization activities that would reduce localized persistent thaw settlement to temporary medium intensity effects.

Summary of Natural Gas Pipeline Impacts

Climate change effects on pipeline permafrost impacts would mostly range from low intensity (e.g., little noticeable additional ground settlement or thermal erosion due to climate change) to medium intensity (e.g., pipeline design and monitoring/maintenance expected to be effective at controlling measurable increases in thaw settlement and thermal erosion due to climate change), although localized conditions could exist that cause high intensity drainage or thaw erosion effects, which could be reduced through additional mitigation (e.g., bonding to cover ROW monitoring and stabilization in post-closure). While climate change effects on permafrost would reach beyond the Project Area, pipeline effects on and from climate-altered permafrost would be localized along intermittent ice-rich areas of the ROW (mostly along the north flank of the Alaska Range between MPs 150 and 215) and within the immediate vicinity of the cleared ROW. Most permafrost thaw effects would range from long-term (e.g., settlement reaches equilibrium within several years) to permanent (i.e., restoration of permafrost not expected).

Discontinuous permafrost and climate change are considered common in context based on their regional to global distribution. Therefore, overall effects would range from minor to moderate.

Summary of Impacts for Alternative 2 – Permafrost

Impacts to and from permafrost due to climate change at the mine site, transportation facilities, and natural gas pipeline under Alternative 2 would range from low intensity (e.g., little noticeable additional ground settlement due to climate change) to medium intensity (e.g., design and BMPs at major mine structures and along pipeline are effective in controlling permafrost hazards, differential settlement, and thermal erosion), although specific low probability conditions may exist that could cause medium to high intensity effects and which could be reduced through additional mitigation (e.g., additional permafrost excavation at toe of WRF). Low intensity beneficial effects (preservation of remaining permafrost) could also occur in some areas following reclamation. While climate change effects on permafrost would be extended, with effects reaching beyond the Project Area, project–related impacts on climate-altered permafrost would be limited to intermittent areas of permafrost and localized beneath facility footprints and cleared areas. Permafrost thaw effects would range from long-term (e.g., settlement and revegetation reach equilibrium within several years) to permanent (i.e., restoration of permafrost not expected). Discontinuous permafrost and climate change are considered common in context based on their regional to global distribution. Effects would range from minor to moderate.

3.26.4.2.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

Vegetation and Wetlands

Climate change effects for biological resources are difficult to quantify, and are presented for all three project components (mine site, transportation facilities, and natural gas pipeline) together.

Impacts of Alternative 2 to vegetation and wetlands are described in Section 3.10, Vegetation, and Section 3.11, Wetlands.

Predicted overall increases in temperatures with precipitation shifts (McGuire 2014; Chapin III et al. 2006, 2010; Walsh et al. 2005) have the potential to influence the projected effects of the Donlin Gold Project on vegetation and wetlands, and by extension, on wildlife and fish resources, and on subsistence. Especially important would be the influences on indirect effects and on the success of reclamation and mitigation efforts. Changes may be positive, neutral, or negative.

Large scale vegetation types community shifts, such as woody vegetation encroachment into tundra and wetland conversion to upland, is expected are anticipated for much of Alaska in the next 100 years (McGuire 2014; SNAP 2012). During the project life (30 years), a substantial increase in woody vegetation that would require more frequent brushing is unlikely (McGuire 2014). Vegetation shifts may be beneficial to reclamation impacts through increased temperatures, resulting in a higher number of growing degree days and longer growing seasons.

Decreased available water may have a negative effect on regrowth. Overall, a drying trend is expected in the region due to large-scale climate shifts, with subsequent vegetation community type shifts from wetland to upland characteristics (Berg et al. 2009; Klein et al. 2005). Wetland reclamation areas may become too dry to qualify as wetlands, requiring adjustment to reclamation plans to meet project goals. Potentially rerouting water courses or adding erosion and sedimentation control measures would add complexity to planned measures.

Construction activities that remove or displace soil and vegetation will disrupt insulting layers, resulting in greater potential permafrost thaw rates. In some locations, permafrost thawing could cause subsidence of the surface, creating wet depressions with subsequent upland conversion in adjacent areas. Reclamation or mitigation goals may be more difficult or challenging in areas where permafrost loss causes more open water due to depressions, particularly along the pipeline corridor. Planned permafrost protective measures may be less effective in a warmed or drier climate.

Potential habitat for invasive species is expected to increase with a warming climate (FWS 2009b). Donlin Gold's Invasive Species Management Plan (detailed in Section 3.10, Vegetation) will build in adaptive management capacity for detection, monitoring, and control approaches to address potential climate change effects.

Increases in fire frequency, extent, and burn severity are predicted within the EIS Analysis Area (Rupp and Springsteen 2009), along with increased insect outbreaks of native insect species such as the spruce bark beetle (Chapin III et al. 2010). Fire prevention measures during all phases of the project would remain important under projected fire regime changes.

Wildlife and Threatened and Endangered Species

Impacts of Alternative 2 to wildlife and TES are described in Section 3.12, Wildlife and Section 3.14, Threatened and Endangered Species.

Vegetation community type changes may impact wildlife habitat positively or negatively. An increase in open water areas may increase habitat diversity and add value for wildlife. An increase in wildfire frequency and intensity may create more early successional vegetation communities favorable to moose. Decreases in coastal winter habitat may reduce food availability for shorebirds. Shifts in populations due to habitat changes combined with construction and operations impacts may require revisions or adaptations to the Donlin Gold Wildlife Avoidance and Human Encounter/Interaction Plan.

Fish and Aquatic

Impacts of Alternative 2 to fish and aquatic resources are described in Section 3.13, Fish and Aquatic.

Impacts to fish and aquatic resources may be positive or negative. Potential food web alterations caused by temperature changes or ocean acidification may have profound impacts to fish populations which are only poorly understood at this time. Warming temperatures may increase habitat potential for some species. Generally, warming is expected to have negative impacts on most salmon species life cycles (Crozier et al. 2014). Potential habitat for non-native species may increase with warmed temperatures. Combined with increased marine and aquatic traffic from construction and operations, potential for aquatic habitat changes exists.

Subsistence

Impacts of Alternative 2 to subsistence resources are described in Section 3.21, Subsistence.

The effects of climate change in Alaska strongly affect Alaska Native communities, which are highly vulnerable to these rapid changes but have a deep cultural history of adapting to change (Chapin III et al. 2014). Subsistence practices may have to be flexible in time, season, and harvest volume to accommodate both habitat and climate shifts and mine construction and operations. For example, a later or earlier run time for certain fish species combined with mine construction and operations may affect individual's ability to access or have time to harvest the species.

Summary of Impacts for Alternative 2 – Biological Resources and Subsistence

The effects of predicted climate change on vegetation and wetlands under Alternative 2 may increase in later project years due to warming temperatures and altered precipitation patterns, resulting in permafrost loss, vegetation type changes, a general drying trend, and changed fire regime. In the pipeline corridor, vegetation removal during construction and operations may accelerate permafrost loss in a warming climate, although construction practices and mitigation measures will be incorporated to prevent unnecessary permafrost loss. In the mine site, construction activities would remove the permafrost, so it would not be further modified by climate change. Fire severity is predicted to increase over time in a warming climate, and the vegetated areas along active roads or other operations areas would be most vulnerable to accidental fire. Shifts in wildlife, fish, or TES populations may occur due to subsequent habitat and precipitation or temperature changes, affecting subsistence resources as well.

Because the effects would be incremental, the intensity of impacts for biological resources and subsistence would be low. The extent would be considered local to regional, and the context would be considered common. Given the expected long range trends of biome shifts, overall effects of climate change on biological resources and subsistence during the life of the project would be minor.

3.26.4.2.5 IMPACT REDUCING MEASURES

These effects determinations take into account impact reducing design features (Table 5.2-1 in Chapter 5, Impact Avoidance, Minimization, and Mitigation) proposed by Donlin Gold and also the Standard Permit Conditions and BMPs (Chapter 5, Impact Avoidance, Minimization, and Mitigation) that would be implemented. Several examples of these are presented below.

Design features most important for reducing impacts from climate change include:

- The project design includes the use of natural gas to fuel the power plant and the other dual-fuel fired units at the mine site, which would result in lowering GHG emissions by 9.6031 MMT during the mine life of 27.5 years compared to diesel fuel.
- There is flexibility built in to the design of mine site water-containment structures, the WTP, and water management strategies that would accommodate potential precipitation increases or decreases, freshwater requirements, or increased storage or treatment needs caused by climate change.
- The barge plan includes several elements that would allow flexibility in managing shipping requirements in low-water years, such as extension of the barge season into shoulder seasons, collection of daily draft data for forecasting river depth, and storage of sufficient inventory for backup supply.

- Strain-based design of the pipeline would accommodate increased differential thaw settlement from permafrost melting.

Standard Permit Conditions and BMPs most important for reducing impacts from climate change include:

- Preparation and implementation of a Stabilization, Rehabilitation, and Reclamation Plan;
- Appropriate bonding / financial assurance; and
- Monitoring of water withdrawals to ensure permitted limits are not exceeded.

Additional Mitigation and Monitoring for Alternative 2

The Corps is considering additional mitigation (Table 5.5-1 in Chapter 5, Impact Avoidance, Minimization, and Mitigation) to reduce the effects presented above. These additional mitigation measures include:

- Donlin should consider replacing culverts along the mine access road with low water crossings at closure to minimize long-term effects of extreme precipitation events and climate change.

The Corps is considering additional monitoring (Table 5.7-1 in Chapter 5, Impact Avoidance, Minimization, and Mitigation) to reduce the effects presented above. These additional monitoring measures include:

- To minimize the effects of climate change, reexamine the continuing applicability of key portions of the water balance model on approximate 10-year intervals as determined by the data collected and operational or closure conditions and experiences. For example, current mine plans for the pit lake during closure indicate that the water level would be monitored and pit lake model recalibrated as data become available. It is recommended that climate change precipitation predictions also be reevaluated periodically in post-closure, and incorporated into water balance and groundwater model updates, in order to adequately anticipate climate change effects on pit filling and other project structures such as reclaim components; and
- As described in Sections 3.2, Soils and 3.5, Surface Water Hydrology, the Stabilization, Rehabilitation and Reclamation (SRR) Plan would cover pipeline termination activities (SRK 2013a), but not necessarily post-closure monitoring by Donlin Gold, which may be required to mitigate long-term effects from climate change such as thaw settlement on the ROW or scour effects in drainages if the abandoned pipeline is uncovered. The need for monitoring and rehabilitation in post-closure should be addressed in the revised SRR Plan prior to closure, and additional financial assurance considered to cover these activities.

If these mitigation and monitoring measures were adopted and required, impacts of climate change to the atmosphere would be negligibly reduced and therefore remain minor. Impacts to water could be somewhat reduced, but would likely remain minor to moderate. Impacts to permafrost could also be reduced somewhat although would remain minor.

3.26.4.3 ALTERNATIVE 3A – REDUCED DIESEL BARGING: LNG-POWERED HAUL TRUCKS

3.26.4.3.1 ATMOSPHERE

Under Alternative 3A, the project would use liquefied natural gas (LNG) instead of diesel to power the large haul trucks to move waste rock and ore from the open pits during operations. These large trucks would account for approximately 75 percent of the total annual diesel consumption in Alternative 2. During operations, Alternative 3A would reduce consumption of diesel, reduce barge trips, and reduce tanker trucks compared to Alternative 2.

No change in diesel consumption would occur at any component of the Donlin Gold Project during construction and closure under Alternative 3A, and thus no change in GHG emissions or climate change impacts for those phases from the levels discussed under Alternative 2 would occur. During operations, GHG emissions would be reduced by about 64,000 tpy of CO_2-e due to reduced diesel consumption at the mine site and corresponding reduced river diesel barging, as compared to Alternative 2 (Cardno 2014b). This is about 0.1 percent of extended CO_2-e emissions of 52.1 MMT in 2005 (ADEC 2008).

LNG burns cleaner than diesel due to its lower carbon content (DOE 2013). Because LNG is a low-carbon, clean-burning fuel, a switch to LNG, especially when considering life cycle emissions, can result in substantial reductions of GHGs compared to diesel (DOE 2013). The reduced diesel consumption under Alternative 3A would not affect GHG emissions associated with the pipeline component.

GHG emissions during operations of the mine site and transportation facilities would be reduced compared to Alternative 2; thus, emissions would remain low in magnitude. For the mine site and transportation facilities, GHG emissions would remain long-term in duration (occurring throughout operations), local in extent (emission sources would occur within the Project Area), and common in context.

<u>Summary of Impacts for Alternative 3A – Atmosphere</u>

GHG emissions would remain low in intensity for the mine site, transportation facilities, and pipeline components under Alternative 3A. GHG emissions would be long-term in duration (occurring throughout operations), and considered local in extent (emission sources would occur only within the Project Area). While GHG emissions would be reduced compared to Alternative 2, the reduction would only be about 0.1 percent of extended CO_2-e emissions. Thus, the overall assessment of climate change impacts from GHG emissions under Alternative 3A would still be minor, similar to Alternative 2.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would remain similar to Alternative 2.

3.26.4.3.2 WATER

Mine Site and Natural Gas Pipeline

The effects of climate change on hydrology impacts for the mine and pipeline components would be the same under Alternative 3A as Alternative 2. Adding an LNG facility at the mine site and reducing tank storage capacity would not change hydrologic effects discussed under Alternative 2, and there would be no changes to the pipeline component under this alternative.

Transportation Facilities

Because the number of barge trips would be reduced under Alternative 3A by more than half, the effects of climate change on Kuskokwim River flow would cause less impact on the project than Alternative 2. With fewer barge trips, there would be almost no need to operate barges on the Kuskokwim River in low water conditions to meet resupply requirements, and there would be less risk of barge stranding or need for other shipping contingencies. Thus, the magnitude of potential climate change effects is expected to be low, in that these effects may or may not be noticeable.

Summary of Impacts for Alternative 3A – Water

While the magnitude of effects on the transportation component under Alternative 3A would be less than that of Alternative 2, the range of effects for the mine and pipeline would remain unchanged, i.e., low to medium (e.g., hydrologic design of major facilities is expected to be adequate to accommodate climate change effects of increased precipitation). Thus, the rating for the project as a whole would be the same as Alternative 2; i.e., minor to moderate.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.3.3 PERMAFROST

Mine Site

The effect of climate change on permafrost impacts depends on the amount of disturbed versus undisturbed soils that would occur under Alternative 3A, as soil removal or other ground disturbances would have a comparatively greater effect on permafrost than climate change, which would cause increased thawing only in areas of undisturbed soils. Because facility footprints and the extent of disturbed soils would be about the same under Alternative 3A as Alternative 2, the effect of climate change on permafrost would be the same.

Transportation Facilities

The reduction in fuel storage expansion at the Bethel dock under this alternative would decrease the extent of permafrost effects. However, because climate change would only cause increased thawing in areas of undisturbed soils, there would be a slight increase in the effects of climate change on permafrost for those soils (approximately 5 acres) that remain undisturbed under this alternative as compared to Alternative 2. This increase would likely result in measurable permafrost thaw (medium intensity) due to climate change for these 5 acres under Alternative 3A; whereas under Alternative 2, the soils would be disturbed and the effects of climate change would not be noticeable (i.e., permafrost thaw would occur regardless of climate change effects). This slight increase in effects under Alternative 3A, however, would not change the range of impact criteria (e.g., low to medium intensity) for Alternative 3A compared to Alternative 2.

Natural Gas Pipeline

The effect of climate change on permafrost impacts associated with the pipeline component of Alternative 3A would be the same as Alternative 2, as there would be no difference in soil disturbance between the two alternatives for the pipeline component.

Summary of Impacts for Alternative 3A – Permafrost

While there could be a slight increase in the effects of climate change on permafrost thaw under Alternative 3A at the Bethel Dock, the increase would be relatively small compared to the project as a whole. Thus, the level of effects would be the same as Alternative 2, i.e., minor to moderate overall.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.3.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

The effects of climate change on impacts of the project on biological resources and subsistence under Alternative 3A would be similar to those described under Alternative 2. Overall impacts from climate change would be minor.

3.26.4.4 ALTERNATIVE 3B – REDUCED DIESEL BARGING: DIESEL PIPELINE

3.26.4.4.1 ATMOSPHERE

Alternative 3B would replace the natural gas pipeline proposed under Alternative 2 with a diesel pipeline. GHG emissions and the resulting impacts to climate change under Alternative 3B would be similar to those discussed under Alternative 2 for construction and closure of all project components, as well as for pipeline operations.

Alternative 3B would result in lower GHG emissions during operations due to reduced barging, and elimination of fugitive GHGs from the natural gas pipeline and compressor station. However, this reduction would be more than offset by increased GHGs from combustion of diesel in the mine site combustion equipment. The magnitude would not be expected to change from Alternative 2 levels for any of the components. The duration, extent, and context of GHG emissions would be similar to those described under Alternative 2.

Summary of Impacts for Alternative 3B – Atmosphere

The intensity, duration, extent, and context of GHG emissions would be similar to those described under Alternative 2. Overall impacts under Alternative 3B would be considered minor.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.4.2 WATER

Mine Site

Hydrologic effects at the mine site due to climate change are expected to be the same under Alternative 3B as Alternative 2. Effects of increased precipitation on the design of major structures would not change under this alternative.

Transportation Facilities

The number of barge trips on the Kuskokwim River would be reduced by about half under Alternative 3B. As a result, the effects of climate change on Kuskokwim River flow are expected to cause less impacts on the project than Alternative 2. With fewer barge trips, there would be almost no need to operate barges in low water conditions to meet resupply requirements, and there would be less risk of barge strandings or need for other shipping contingencies. Thus, the magnitude of potential climate change effects is expected to be low, in that these effects may or may not be noticeable.

Diesel Pipeline

The additional section of pipeline between Tyonek and Beluga under this alternative would cross an additional 5 streams using open cut methods. Predicted climate change effects on precipitation along this section of the pipeline are similar to other sections of the pipeline in the Cook Inlet basin. There could be a slight increase in potential erosion and scour under this alternative due to the additional stream crossings; however, the magnitude of effects for all stream crossings would be the same as described under Alternative 2, i.e., low to medium (e.g., design burial depths anticipated to be adequate for conditions).

Summary of Impacts for Alternative 3B – Water

The magnitude of effects on the transportation component under Alternative 3B would be less than that of Alternative 2, but would be balanced somewhat by slightly greater effects along the pipeline. The range in magnitude of the effects for all project components would be the same as Alternative 2, i.e., ranging from low (e.g., climate change effects on Kuskokwim River barging may or may not be noticeable) to medium (e.g., hydrologic design of major facilities adequate to accommodate climate change effects of increased precipitation). Thus, the rating for the project as a whole would be the same as Alternative 2; i.e., minor to moderate.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.4.3 PERMAFROST

Mine Site

The slight reduction in footprint of the fuel storage area at the mine site under Alternative 3B is likely to be offset by use of the same area for other purposes (e.g., laydown). Because there would be almost no difference in soil disturbance between Alternatives 2 and 3B, the effects of climate change on permafrost impacts would be considered the same.

Transportation Facilities

The area of soil disturbance at the Angyaruaq (Jungjuk) and Bethel ports is expected to be approximately the same under this alternative as Alternative 2; thus, the effect of climate change on permafrost would be the same. There would be no change in effects due to the addition of the Tyonek dock and tank farm under this alternative, as no permafrost is expected in this area.

Diesel Pipeline

There would be no change in effects due to the addition of the Tyonek to Beluga section of the pipeline under this alternative, as no permafrost is expected in this area. Permafrost-related ground deformation associated with this alternative in the absence of climate change is expected to be similar to Alternative 2, as the diesel would be within a few degrees of ambient ground conditions and ROW clearing-related effects would be the same. The effects of climate change on permafrost impacts under this alternative are also expected to the same as Alternative 2, as the amount of soil disturbance in permafrost areas would be about the same between the two alternatives.

Summary of Impacts for Alternative 3B – Permafrost

While there would be differences in soil disturbance between Alternatives 3B and 2, most of these are located in areas with no permafrost. Thus, the level of effects would be the same as Alternative 2, i.e., minor to moderate overall. Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.4.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

The elimination of diesel barging on the Kuskokwim River would reduce but not eliminate the risk of introducing aquatic and terrestrial invasive species. The addition of a diesel fuel barge from either northwest marine terminals or Nikiski to Tyonek would impact vegetation in the vicinity of Tyonek through direct vegetation removal for a new dock and tanks, or by increasing the potential for introduction of new invasive species or spread of existing known invasive plant species in Tyonek. Invasion prevention and management practices would not change; design features, Early Detection and Rapid Response principles, BMPs, and an adaptive Invasive Species Management Plan (ISMP) would remain the same as in Alternative 2.

The effects of climate change on impacts of the project on biological resources and subsistence under Alternative 3B would be similar to those described under Alternative 2, but would cover a slightly larger area during operations. Overall impacts from climate change would be minor.

3.26.4.5 ALTERNATIVE 4 – BIRCH TREE CROSSING PORT

3.26.4.5.1 ATMOSPHERE

Alternative 4 would move the location of the Angyaruaq (Jungjuk) Port and mine access road in Alternative 2 to BTC. This would result in reduced distance of river barging and longer road trips between the BTC Port and the mine site. Project-related activities for the transportation facilities would have slightly higher GHG emissions during the construction and reclamation and closure of the longer access road under Alternative 4. During operations, project–related activities for the transportation facilities would have reduced GHG emissions from barging, but increased GHG emissions from the increased distance trucks would have to travel on the mine access road when compared to Alternative 2. No changes in GHG emissions would occur under Alternative 4 for any phases of the mine site or pipeline components.

<u>Summary of Impacts for Alternative 4 – Atmosphere</u>

Overall, Alternative 4 would have a slight increase in GHG emissions during operations of the transportation facilities when compared to Alternative 2. At most, impacts to climate change would be minor under Alternative 4, similar to Alternative 2.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.5.2 WATER

<u>Mine Site and Natural Gas Pipeline</u>

The effects of climate change on hydrology impacts for the mine site and pipeline would be the same under Alternative 4 as Alternative 2, as there would be no change in proposed facilities for these two components.

Transportation Facilities

Barging

Under Alternative 4, the number of barge trips on the Kuskokwim River would be the same, but the round trip travel distance would be reduced by about 40 percent. In addition, several critical (shallow) sections of the river upstream of the BTC Port would be avoided under this alternative. However, there would still be two critical sections of the river downstream of the BTC Port under Alternative 4 (Figure 3.5-29, Surface Water Hydrology).

The flow cutoff for operating on the lower section of the river is the same as that of the upper river (greater than 39,000 cfs at the Crooked Creek gauge), because Nelson Island below BTC is the controlling case. That is, the flow needed to get through Nelson Island under Alternative 4 is the same as the flow needed to get to Angyaruaq (Jungjuk) Port under Alternative 2 (Enos 2014). With a shorter barge travel time, fewer barge days would be required under this alternative to meet fuel and cargo shipping requirements, and the need for seasonal changes or other contingencies would be reduced.

As a result, the effects of climate change on Kuskokwim River flow are expected to cause less impact on the project under Alternative 4 than Alternative 2. With shorter barge trips and fewer barge days, there would be almost no need to operate barges in low water conditions to meet resupply requirements, and there would be less risk of barge strandings or need for other shipping contingencies. Thus, the magnitude of potential climate change effects is expected to be of low intensity, in that climate change potentially reducing summer flows on the river is not likely to have a noticeable effect on the project.

BTC Road

Predicted climate change effects on precipitation in the vicinity of the BTC Road (e.g., see Aniak, Table 3.26-4) are similar to those predicted for the mine access road under Alternative 2. While there would be an increased number of bridges and culverts along the BTC Road as compared to the mine access road, the range of magnitude associated with these effects would be the same for both alternatives; i.e., the effect of climate change on their design is expected to be low to medium, in that the effects may or may not be noticeable and designs based on extreme events are expected to be adequate for conditions.

Summary of Impacts for Alternative 4 – Water

While the magnitude of effects on the transportation component (barging) under Alternative 4 would be less than that of Alternative 2, the range of effects for the mine site, transportation facilities (BTC Road), and pipeline would remain unchanged, i.e., low to medium (e.g., hydrologic design of major facilities expected to be adequate to accommodate climate change effects of increased precipitation). Thus, the ratings for the project as a whole under Alternative 4 would be the same as Alternative 2; i.e., minor to moderate.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.5.3 PERMAFROST

Mine Site and Natural Gas Pipeline

The areas of soil disturbance for the mine site and pipeline components under Alternative 4 would be the same as Alternative 2. Thus, the effects of climate change with respect to permafrost would be the same.

Transportation Facilities

Impacts to and from permafrost under this alternative in the absence of climate change are expected to be greater than those of Alternative 2, due to the increased length of the BTC Road and Crooked Creek temporary ice road crossing permafrost areas. However, because the permafrost areas along the BTC Road would be covered by geotextile and fill, climate change is expected to have little effect on increasing the rate of thaw or differential settlement, due to the insulating and strength effects of the added material.

Climate change could increase permafrost degradation effects along the Crooked Creek ice road, depending on the degree of vegetation and soil compaction beneath the ice. Effects in the absence of climate change may or may not be noticeable and would be temporary to long-term; effects with climate change are more likely to be noticeable and long-term, depending on the rate of vegetation recovery. This increase in effects for the Crooked Creek ice road, however, would not change the range of impact criteria (e.g., low to medium intensity) for the transportation facilities combined under Alternative 4 as compared to Alternative 2.

Summary of Impacts for Alternative 4 – Permafrost

While there could be an increase in the effects of climate change on permafrost thaw under Alternative 4 along the Crooked Creek ice road, the increase would be relatively small compared to the project as a whole. Thus, the level of effects would be the same as Alternative 2; i.e., minor to moderate overall.

Design features, Standard Permit Conditions, and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.5.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

The longer port road and ice road would cause an additional 918.4 acres of direct vegetation removal, resulting is a higher risk of invasive species introduction or spread. Invasion prevention and management practices would not change; design features, Early Detection and Rapid Response principles, BMPs, and an adaptive ISMP would remain the same as in Alternative 2.

The effects of climate change on impacts of the project on biological resources and subsistence under Alternative 4 would be similar to those described under Alternative 2, but would cover a slightly larger area during operations. Overall impacts to from climate change would be minor.

3.26.4.6 ALTERNATIVE 5A – DRY STACK TAILINGS

3.26.4.6.1 ATMOSPHERE

Alternative 5A includes variations in tailings methods within the mine site. This action would not cause a substantial change in GHG emissions or impacts to climate change in any of the phases or project components from those identified under Alternative 2. Overall direct and indirect impacts related to climate change would be minor under Alternative 5A, similar to Alternative 2.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.6.2 WATER

Mine Site

Construction, and Operations and Maintenance

Alternative 5A (both Options 1 and 2) would involve slightly different major water-retaining structures than Alternative 2, that could be affected by the predicted increase in precipitation caused by climate change. Under Alternative 5A, a dry stack tailings pile would be constructed behind an upper dam in the Anaconda Creek drainage, and the main TSF dam would be used to hold an operating pond. The dam design criteria with respect to IDF would be the same as the TSF dam under Alternative 2 (BGC 2014a). Thus, the effects of extreme hydrologic events on Alternative 5A would be considered the same as Alternative 2. The upper operating pond dam would limit seepage of infiltrated water (under both options) and groundwater (under Option 1) through the dam that accumulates in the dry stack. The dry stack would either be unlined (Option 1) or have a rock overdrain (Option 2) to provide drainage and enhance stability of the stack in the event of higher precipitation conditions due to climate change.

Stochastic water balance models (WBMs) have been developed for Alternative 5A, which take into account the same wet and dry climate scenarios as under Alternative 2 (that is, WBM runs based on 10^{th} to 99^{th} percentile precipitation conditions) (BGC 2015j). These provide results over a greater range of conditions than the predicted average annual climate change increase over the operations period of 2 to 3 percent. For example, WBMs for Alternative 5A predict that, if 99^{th} percentile precipitation conditions occur continuously over the mine life, the ultimate cumulative TSF operating pond volume would be about 20 percent higher than the 50^{th} percentile or average condition (99,000 vs. 82,000 acre-feet, respectively). Both of these are well within the total storage capacity of the pond, about 125,000 acre-feet, as it is designed to store an extra year of contingency water production (BGC 2014a). The total storage capacity of pond under Alternative 5A is about 50 percent higher than the average precipitation condition.

The effects of a 25 percent climate-caused precipitation increase on pit dewatering volume, and on the amount of freshwater needed from Snow Gulch reservoir, would be the same under Alternative 5A (both options) as for Alternative 2. In addition, the flexibility provided by the

AWT WTP design under Alternative 2 would be the same under Alternative 5A. Flexible mine site water management under Alternative 5A means that major water containment structures would be able to accommodate extra runoff and dewatering water from potential climate change precipitation increases. Thus, the magnitude of potential climate change effects on major mine structures in operations under Alternative 5A is considered medium (likely to be adequate for conditions).

Closure, Reclamation, and Monitoring

Because the operating pond and other water dams would be removed in closure, the effects of climate change on pond volumes and related water management activities would be considered long-term and would not occur in post-closure. There would be an increased rate of seepage flow to the SRS in post-closure under Option 1 (unlined dry stack), which would be pumped to the pit lake. Under Option 2 (lined dry stack), the same increased seepage flow (compared to Alternative 2) would report directly to the pit lake in post-closure. Because the increased volume of seepage flow through the dry stack under both options of Alternative 5A compared to Alternative 2 (about 30 to 80 gpm more) represents a relatively small amount of the total water filling in the pit lake from other sources (about 4,000 gpm), the effect of increased precipitation from climate change during post-closure would be about the same as Alternative 2; i.e. the management of water levels to maintain freeboard would be similar and, like Alternative 2, would be conducted in perpetuity.

Summary of Mine Site Impacts

The magnitude of climate change effects on major structures and water management at the mine site is expected to be low to medium (e.g., effects may or may not be discernable beyond extremes predicted by the historical record, and hydrologic designs adequate to accommodate most climate change effects). The duration, geographic extent, and context of climate change effects would be the same as Alternative 2. Overall effects of climate change on hydrology impacts are considered mostly minor to moderate.

<u>Transportation Facilities and Natural Gas Pipeline</u>

The effects of climate change on hydrology for transportation facilities and the pipeline would be the same under Alternative 5A as Alternative 2, as there would be no change in proposed facilities for these two components of the project.

<u>Summary of Impacts for Alternative 5A – Water</u>

The magnitude of hydrologic effects due to climate change under Alternative 5A (including effects on transportation and pipeline components which do not change under this alternative from Alternative 2) would mostly range from low (e.g., effects may or may not be discernable beyond extremes predicted by the historical record) to medium (e.g., sufficient barging days available to meet shipping needs). The duration, geographic extent, and context of climate change effects would be the same as Alternative 2. Overall effects of climate change on hydrology are considered mostly minor to moderate, with a low probability of major effects that could be reduced to moderate through additional mitigation.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.6.3 PERMAFROST

Mine Site

Soil and permafrost disturbances beneath the dry stack tailings and operating pond under Alternative 5A would be slightly greater than those for Alternative 2, but not significantly different. Permafrost excavation beneath the dam footprints would be higher under Alternative 5A, increasing the amount of this material stored in the TSF overburden stockpile and the amount of permafrost melting in the pile; however, this effect is expected to occur in the absence of climate change. Thus, the effects of climate change on permafrost impacts under this alternative are expected to be the same as Alternative 2.

Transportation Facilities and Natural Gas Pipeline

The areas of soil disturbance for the transportation and pipeline components under Alternative 5A would be the same as Alternative 2. Thus, the effect of climate change on permafrost impacts would be the same.

Summary of Impacts for Alternative 5A – Permafrost

While there could be a minor increase in permafrost impacts under Alternative 5A associated with the mine site, the effects of climate change would be the same as Alternative 2. Thus, the level of effects would be the same as Alternative 2, i.e., minor to moderate overall. Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.6.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

The change in tailing disposal method would directly affect biological resources by reducing the amount of vegetation disturbance at the mine site slightly. The effects of climate change on impacts of the project on biological resources and subsistence under Alternative 5 would be similar to those described under Alternative 2. Overall impacts from climate change would be minor.

3.26.4.7 ALTERNATIVE 6A – MODIFIED NATURAL GAS PIPELINE ALIGNMENT: DALZELL GORGE ROUTE

3.26.4.7.1 ATMOSPHERE

Alternative 6A would not cause a substantial change in GHG emissions or impacts to climate change in any of the phases or project components from those identified under Alternative 2.

Overall direct and indirect impacts to climate change would be considered minor under Alternative 6A, similar to Alternative 2.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.7.2 WATER

Mine Site and Transportation Facilities

The effects of climate change on water impacts for the mine and transportation facilities would be the same under Alternative 6A as Alternative 2, as there would be no change in proposed facilities for these two components of the project.

Natural Gas Pipeline

The alternate pipeline route through the Alaska Range under Alternative 6A would traverse high mountain terrain that is expected to have similar climate change impacts to hydrology as that of the Alaska Range section of Alternative 2. Based on mapped SNAP (2012) data, precipitation is predicted to increase as much as 15 percent in the Alaska Range over the life of the mine. The monthly distribution of precipitation changes at lower elevations along the alternative route are expected to be similar to that of Skwentna (Table 3.26-5)).

Increased precipitation and breakup discharge due to climate change could cause an increase in the occurrence of glaciation or aufeis effects at co-located ROW and INHT segments between MP 84 and MP 142 of Alternative 6A. Localized glaciation is known to occur along the trail in the Alaska Range in winter, a situation which could be exacerbated by the co-located pipeline ROW near stream crossings and be hazardous for trail users. While BMPs and regular operations activities would minimize these effects, incremental glaciation effects from climate change could be greater under Alternative 6A than Alternative 2, due to the greater number of trail crossings and co-located segments under Alternative 6A (21 more crossings and 10.5 more co-located miles).

The predicted magnitude of hydrologic climate change effects would be similar between the Alternative 2 and 6A routes, although the extent of potential increased glaciation effects could be greater under Alternative 6A. However, the range of overall effects under this alternative would be the same as Alternative 2, i.e. minor to moderate.

Summary of Impacts for Alternative 6A – Water

The hydrologic effects of climate change for the mine site, transportation facilities, and natural gas pipeline under Alternative 6A would be the same as Alternative 2, i.e., minor to moderate overall. Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.7.3 PERMAFROST

Mine Site and Transportation Facilities

The areas of soil disturbance for the mine and transportation components under Alternative 6A would be the same as Alternative 2. Thus, the effect of climate change on permafrost impacts would be the same.

Natural Gas Pipeline

As described in Section 3.2, Soils, there appears to be less permafrost occurrence and related impacts along the Alaska Range section of Alternative 6A than that of Alternative 2. However, this is based on data of varying quantities and confidence between the two routes, and ground conditions are more likely to be similar with regard to permafrost between the two alternatives. Thus, the effect of climate change on permafrost impacts along Alternative 6A is expected to be roughly the same as Alternative 2.

Summary of Impacts for Alternative 6A – Permafrost

While there could be minor differences in permafrost impacts between Alternatives 6A and 2, these differences and the effects of climate change would likely be small compared to those of the project as a whole. Thus, the level of effects would be the same as Alternative 2, i.e., minor to moderate overall. Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Additional mitigation and monitoring measures that could be implemented to further reduce impacts are also described in Alternative 2. If these mitigation measures were adopted and required, the summary impact rating would be similar to Alternative 2.

3.26.4.7.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

The effects of climate change on impacts of the project on biological resources and subsistence under Alternative 6 would be similar to those described under Alternative 2. Overall impacts from climate change would be minor.

3.26.4.8 IMPACT COMPARISON – ALL ALTERNATIVES

A comparison of the impacts to climate change by alternative is presented in Table 3.26-14.

Table 3.26-14: Climate Change Effects Summary Comparison*

Alternative 2 – Donlin Gold's Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B – Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A – Dry Stack Tailings	Alternative 6A – Dalzell Gorge Route
Atmosphere					
Impacts intensity of GHG emissions would be considered low to medium, representing at most 0.023 percent of U.S. total GHG emissions in 2012. Duration of impacts would be long-term, with GHG emissions occurring throughout the duration of the project, local in extent (occurring in Project Area), and common in context. **Overall effects would be minor.**	GHG emissions would be low in intensity for all project components, long-term in duration (occurring throughout operations), and local in extent (emission sources would occur only within the Project Area). GHG emissions reduction would only be about 0.1 percent of extended CO_2-e emissions. **Overall effects would be minor.**	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Water					
Hydrologic effects would range from low intensity to medium intensity with the duration of climate change effects being long-term to permanent, with potential impacts lasting through the project life (transportation and pipeline components) and in post-closure (mine site). The extent would be local to regional, and the context of climate change effects on water is considered common to important> **Overall effects would be minor to moderate.**	Less potential for low water barge impacts (fewer trips needed). Overall same as Alternative 2.	Slightly less effects along transportation corridor (fewer barge trips); slightly more effects along pipeline (more stream crossings subject to climate effects). Overall same as Alternative 2.	Less potential for low water barge effects. Overall same as Alternative 2.	Flexible mine water management and design of operating pond would be able to accommodate climate-caused precipitation changes. Overall same as Alternative 2.	Potential for slightly higher climate-caused precipitation and aufeis effects: 21 more stream crossings and 10.5 more miles co-located with INHT. Overall same as Alternative 2.

Table 3.26-14: Climate Change Effects Summary Comparison*

Alternative 2 – Donlin Gold's Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B – Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A – Dry Stack Tailings	Alternative 6A – Dalzell Gorge Route
Permafrost					
Impacts to and from permafrost for all components would range from low to medium intensity, although specific low probability conditions may cause medium to high intensity effects which could be reduced through additional mitigation. Low intensity beneficial effects (preservation of remaining permafrost) could also occur in some areas following reclamation. While climate change effects on permafrost would be extended in extent, project–related impacts on climate-altered permafrost would be limited to intermittent areas of permafrost and localized beneath facility footprints and cleared areas. Permafrost thaw effects would range from long-term to permanent. Discontinuous permafrost and climate change are considered common in context. **Overall effects would be minor to moderate.**	Same as Alternative 2. While there could be a slight increase in the effects of climate change on permafrost thaw at the Bethel Dock, the increase would be relatively small compared to the project as a whole. **Overall effects would be minor to moderate.**	Same as Alternative 2.	Slightly more climate-caused effects along Crooked Creek ice road. Overall same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Biological Resources					
Because effects on biological resources (primarily vegetation and wetlands) would be incremental, the intensity would be low. The extent would be local to regional, and the context would be common. **Overall effects would be minor.**	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

Table 3.26-14: Climate Change Effects Summary Comparison*

Alternative 2 – Donlin Gold's Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B – Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A – Dry Stack Tailings	Alternative 6A – Dalzell Gorge Route
Subsistence					
Because effects on subsistence resources (primarily flexibility in time season, and harvest volume) would be incremental, the intensity would be low. The extent would be local to regional, and the context would be common. **Overall effects would be minor.**	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

Notes:

* The No Action Alterative would have no impacts.